HAER
CONN
6-NEWLO,
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NAVAL UNDERSEA WARFARE CENTER
(Fort Trumbull)
East side of Smith and East Streets,
between Columbia Cove and South Cove
New London
New London County
Connecticut

HAER No. CT-180

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
Philadelphia Support Office
U.S. Custom House
200 Chestnut Street
Philadelphia, Pennsylvania 19106

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Location: East side of Smith and East Streets, between Columbia Cove and South Cove. New London, New London County, Connecticut.

USGS New London, CT Quadrangle
Universal Transverse Mercator Coordinates
A. 18.743060.4580540
B. 18.743240.4580600
C. 18.743250.4580770
D. 18.743160.4581200
E. 18.742900.4581120

Date of Construction: 1777-1990.

Engineers/Architects: Simon Bernard, Joseph G. Totten, Alfred A. Hopkins, U.S. Navy Bureau of Yards and Docks.

Present Owner: Caretaker Site Office, Naval Facilities Engineering Command, Northern Division.

Present Use: Mostly vacant, formerly used as a naval research center. A Coast Guard station is operating on the site.

Significance: Initially built as a fort during the Revolution, the site is significant as a 19th century coastal fort. It is also significant for its use as the Coast Guard Academy (1910-1933), the U. S. Maritime Commission Officers Training School (1938-1945), and as the U. S. Navy's primary underwater communications and sonar research facility (1917-1997).

Project Information Statement: The U.S. Navy is planning disposal of this base. To mitigate the adverse effect of potential building demolitions, the SHPO stipulated documentation of the site.

Project Historians: Steven Bedford Ph. D., and Linda Perelli Wright, Fitzgerald & Halliday, Inc., 157 Oxford Street, Hartford, CT, 06105.

PHYSICAL DESCRIPTION

The Naval Undersea Warfare Center (NUWC) New London Division is located in the City of New London in New London County, Connecticut. Located in the southern portion of the city, the NUWC property, originally known as Fort Trumbull, consists of approximately 32.3 acres and is bounded on the north, east, and south by the Thames River and on the west by Smith and East Streets, bordering a mixed-use community. To the east, across the Thames, in the Town of Groton, Connecticut, is the Electric Boat Division of General Dynamics Corporation, a major submarine production facility. Additionally, approximately 3.75 miles to the northeast, in the Gales Ferry section of the Town of Groton, is the Naval Submarine Base New London.

Geographically, the City of New London is part of Connecticut's Eastern Coastal Slope area, which lies along the southeast coast of the state. Its topography is characterized by uniformly low hills and it is forested with hardwoods typical of the central eastern seaboard. Along the shoreline, the bedrock is occasionally exposed, creating natural harbors, inlets, marshes, and beaches. The NUWC site is typical of this area, being located on a rocky point of this type that projects into the Thames River.

NUWC has a main entrance at the intersection of Walbach and East Streets, with a northern entrance at Hamilton Street and a southern entrance at Trumbull Street. Guardhouses are found at each entry. There are also four piers on the site, ranging from approximately 150' to over 600' in length.

The central fixture of the site is the 1849 "Third System" stone fortress, Fort Trumbull, which stands on the highest ground of the peninsula, near the southern end. The fort is surrounded by 47 buildings and structures, ranging in construction date from c. 1830 to 1990. They are arranged around the fort in an informal grid, with different areas loosely grouped according to their uses and period of construction.

The southern portion of the site slopes southward from the low promontory occupied by the Fort and three other buildings constructed before 1860. These buildings were built using granite block and include Stone Row (Building 27), which was used to house officers, Harder Hall (Building 13), used as soldiers barracks, and the former hospital (Building 14). On the southwestern boundary of the site is a one-story, concrete block maintenance building (Building 8), while modern ranch-house style officers' quarters (Buildings 84 and 85) wrap around the southern wall of the fort. To the east and southeast of the fort, at the foot of the promontory, aligned along the river, are a series of research and test facilities, dominated by Building 94, the periscope test facility with a 70' test tower.

Immediately north and west of the fort, on the down slope of the promontory, are six buildings, laid out in a tight informal gird (Buildings 34, 36, 37, 41, 43, 44). Originally built in 1943 to house the

Maritime Commission Officers School, these wood-frame structures vary in height from one to three stories and were designed in the Colonial Revival Style. Slightly to the east of this grouping are Buildings 28 and 45. Building 28 is an International Style structure that occupies the northeastern end of the peninsula's promontory, while Building 45, the Coast Guard station, lies at the foot of the promontory adjacent to the river.

The northerly portion of the NUWC site is dominated by massive, two-and-three-story buildings, which were built between 1960 and 1990 (Buildings 80, 96, 99 and 2). These huge structures were designed specifically as research and development laboratories. They are all steel and concrete frame structures, with brick or precast concrete facades.

The northernmost section of NUWC is sparsely occupied. A fire station (Building 38) is located at the northernmost end. A small memorial park to those New London-trained Merchant Marine officers killed during World War II lies opposite a two story wood frame building that is still extant from the Officers School.

HISTORICAL CONTEXT

Portions of the Naval Undersea Warfare Center (NUWC) New London site have been continuously occupied by the military for over 200 years. The site is unique in that it has survived as a thriving military center throughout this period, serving the following uses:

- Revolutionary War fort
- Federal fort in the newly-forming United States of America
- 1812 harbor defense fortress
- Third System coastal defense
- Recruiting, training, and holding station during the Civil War
- U.S. Revenue Cutter Service Academy (later the Coast Guard Academy) 1910-1932
- Navy submarine research station during World War I
- Home of the Merchant Marine Training School (1938-1945)
- University of Connecticut branch (1946-1950)
- Navy Cold War research station (1946-1997)

These multiple uses have resulted in the presence of what amounts to a three-dimensional palimpsest that reflects the site's sensitive history. Located on a rocky projection, or neck, into the lower Thames River, the site has been manipulated over the years to expand the available space and to adapt the surface to the changing needs of the military. This document chronicles the progression of uses and military developments on the site, and their relationship to regional and national events.

European Contact, 1614-1658

There is no archaeological evidence that the Pequots or the Mohegans, who inhabited the New London area when Europeans began settlement in the 1600s, made use of the NUWC site, although the jutting rocky point was identified as Mamacock in the Algonquian language.[1] In the early 1630s, as first the Dutch and then the English attempted to settle southeastern Connecticut, relations between the colonists and the Native Americans were friendly. However, as more land was acquired from the Native Americans, sometimes by devious means, relations became strained. This hostility was exacerbated by the tensions among the different Connecticut tribes.

The tension soon came to violence between the tribes and the settlers, culminating in the Pequot War of 1635-1637. Groups of English settlers banded together, joined with the Mohegans, and attempted to exterminate the Pequots. One of the English leaders of this effort was Captain Israel Stoughton of Boston. Stoughton came to Pequot Harbor (later known as New London Harbor) with 120 men on a mission to extirpate the Pequots. He set up the "first English houses" in New London (or Pequot, as it was then called), which likely consisted of "a large barrack for temporary summer shelter, and some huts or wigwams near it; the whole surrounded with facines or palisades for defense".[2] The encampment was allegedly located within the NUWC New London bounds (then known as Mamacock). The Pequots were almost exterminated by this war, after which European settlement of New London (then Pequot) began.

New London Settlement, 1658 to 1775

Further tension between the English and Native Americans resulted in King Philip's War of 1675-1676. Following the subjugation of all the surrounding tribes during that war, European settlement accelerated, and exploitation of the area's natural resources became the focus of local economic development. Fishing, oystering, and shipbuilding were the primary early industries in New London. Although Connecticut in general conducted little foreign trade, what did occur was almost wholly concentrated in the New London area.

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[1] TAMS Consultants, Inc. and Historical Perspectives, Inc., "Cultural Resources Survey, Naval Undersea Warfare Center," (U.S. Department of the Navy, Naval Facilities Engineering Command, Northern Division, 1999): p. 3-3.

[2] Frances Manwaring Caulkins, *History of New London, Connecticut; From the First Survey of the Coast in 1612, to 1860* (New London, Connecticut: H.D. Utley, 1895): p. 36.

Despite New London's boom, Mamacock, which ultimately became the site of the NUWC, was not considered a suitable site for building. A rocky outcropping separated from the mainland by marshes, it was deemed useless by New Londoners except for the cultivation of salt hay.[3] Accordingly, when the town was being settled, the point was divided into two-acre lots. No surviving map depicts who these original landowners were.[4]

During most of the eighteenth century, New London grew and flourished with a thriving maritime trade, becoming one of the wealthiest towns of the Connecticut Colony and the third largest in population. Because New London's economy was so dependent on trade, the British decision in the 1770s to subordinate maritime commerce through a series of taxes caused economic difficulty and extreme outrage in southeastern Connecticut.

The Revolutionary War Era and the Original Fort Trumbull, 1775-1782

In the 1770s, as war with England became inevitable, the circumstances demanded measures to protect New London, both because of its wealth and its staunchly revolutionary citizens. Prior to the outbreak of hostilities, the Connecticut Colonial Assembly sent Colonel Josiah Elderkin, an engineer from Windham, to inspect the Connecticut shoreline and make recommendations for fortifications. In 1775, Colonel Elderkin proposed the construction of fortifications on each side of the Thames River, one in Groton and one in New London. Elderkin recommended that an 80' long rampart facing east, north, and south, be built at Mamacock in New London. This rampart was built, and secondary sources assert that a blockhouse for munitions storage was built inside the earthworks.[5] The fortifications were apparently begun in 1775, named and dedicated in 1776 as Fort Trumbull for then Governor Jonathon Trumbull, but not completed until 1777.

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[3]Caulkins, op. cit., 5.; and Dwight C. Lyman, *Two Hundred Years of Fort Trumbull: Remarks at Bicentennial Military Dedication, 5 July 1976, New London, Connecticut* (East Lyme, Connecticut: Brink Press, 1976), p. 3.

[4] TAMS Consultants, Inc. and Historical Perspectives, Inc., op. cit., p. 3-6.

[5] Caulkins, op. cit., p. 519; and Harold F. O'Neil, *Fort Trumbull, New London, Connecticut*, typescript on file at New London County Historical Society, n.d.: p. 4; and John Campbell, "Fort Trumbull, New London, Connecticut," *A Report on Barracks and Hospitals with Descriptions of Military Posts*, Circular No. 4, War Department, Surgeon General's Office (Washington, D.C.: Government Printing Office, 1870): p. 22.

Richard Gridley's Map (circa 1780) and Lyman's Map of the Battle of New London (1781) show the earliest-known visual representations of Fort Trumbull.[6] They are similar in their lack of detail, depicting the fort as an asymmetrical earthwork facing the Thames River, and open to the west. This is in accordance with the descriptions in secondary reports.[7] No other structures in the area of Fort Trumbull are apparent on these maps. However, since both of these maps are obviously rough sketches, it is impossible to conclude that other structures were not present at this time.

During the Revolutionary War, the Britisb embargo and the possibility of attack hindered New London's trading and whaling business, but the war provided a new means of livelihood -- privateering. This was essentially a form of legalized piracy, in which former fishermen and whalers turned to capturing British merchant ships and confiscating their cargoes and ships as payment. New London's sailors became quite adept at this activity. One source claimed that a shortage of volunteers at Fort Trumbull during the Revolutionary War was the result of the exciting and lucrative privateering trade.[8] Early in September 1781, the British ship was captured and brought into New London harbor by privateers. Possibly as a response, Sir Henry Clinton, Commander of British Forces in New York, ordered Benedict Arnold (a native of New London County) to attack New London Harbor on September 6, 1781.

Upon arrival by sea, Benedict Arnold disembarked his forces evenly on both sides of the Thames River with the intention of outflanking the town's defenses. Fort Trumbull, then occupied by only 23 men, stood no chance against Arnold's land attack. The fort's defenders fired one volley, and tben followed orders to retreat to Fort Griswold, which was also under siege and was later captured by the British. After his successful attack on the forts, Benedict Arnold burned the town of New London to the ground.[9] After tbe Revolution, Fort Trumbull fell into decay.

Post-Revolutionary Fort Trumbull, 1783-1800

In 1793, as war broke out in Europe following the French Revolution, American relations with France declined, and a period often called the "Quasi-war with France" ensued. Connecticut's General Assembly again considered the matter of harbor defenses, but declined to mount cannon in

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[6] Maps on file at the New London County Historical Society.

[7] Caulkins, op. cit., loc. cit.; and O'Neil, op. cit., loc. cit.; and Campbell, op. cit., loc. cit.

[8] Lyman, op. cit., p. 7-8.

[9] "Burning of New London," *Connecticut Gazette*, 7 September, 1781.

the defense of New London. In the spring of 1794, however, the U.S. Congress authorized money for the construction and repair of coastal fortifications (the birth of the First System of Coastal Defenses, which spanned from 1794 to 1805) and authorized the President to receive lands ceded for the states for use in coastal defense (1 Stat. 345). Local accounts claim that the money was not adequate for the extensive repairs that Fort Trumbull needed, and volunteers from New London worked to repair the fort. [10]

According to plans in 1794, the renovated Fort Trumbull reservation was to contain 12 heavy cannon, an earthen parapet for 12 pieces of artillery, 12 embrasures, 12 platforms, a 100-foot square redoubt, a magazine, embrasures for 4 field pieces, a block house or barracks for 50 men, and a palisaded enclosure. To be assigned to the fort would be one subaltern, one sergeant, one corporal, two musicians, and 17 privates. The garrison was to be 23 men, increased in times of war to 50, and in case of attack, up to 1,000. [11] It is likely that the extant Blockhouse (Building 42) on the NUWC site was the block house built at this time. [12]

Inspections by the governor later in the same year found that:

> [Fort Trumbull] consists...of a citadel in stone masonry, bomb proof, covering a powder magazine, and will serve for the garrison to live in time of peace. The citadel is surrounded with batteries and glacis, to cover it from the direct fire of ships of war, and to scour the entrance of the harbor and the neighborhood of the citadel with cannon and musketry...there is also a reverberatory furnace for heating balls.[13]

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[10] Lyman, op. cit., 11-12; and O'Neil, op. cit., 6; and L.W.Labaree and C. Fennelly, eds., *The Public Records of the State of Connecticut 1793-1796*, vol. 8 (Hartford, Connecticut: Connecticut State Library, 1951): x.

[11] Walter Lowrie, ed., *American State Papers-Military Affairs*, vol. 1 (Washington, D.C.: Gales and Seaton, 1832-1861): p. 72.

[12] Controversy exists over the date of the extant Blockhouse, with some sources claiming that it was built as a part of the Revolutionary War fort, and others that it was constructed in the 1790s. Further discussion may be found in TAMS Consultants, Inc. and Historical Perspectives, Inc., "Cultural Resources Survey, Naval Undersea Warfare Center," p. 3-8.

[13] Lowrie, ed., op. cit., vol. 1: p. 73.

In 1798, legislation was finally passed in Connecticut authorizing the governor to turn both Fort Trumbull and Fort Griswold over to the federal government.[14] It appears that no further construction activity occurred at the fort for the remainder of the century.

The War of 1812 and the Reconstruction of Fort Trumbull, 1800-1815

At the beginning of the nineteenth century, Fort Trumbull was abandoned to yet another period of inactivity. However, on the national scene, resentment of Great Britain's failure to withdraw from the Great Lakes and of British domination of the seas, which often led to impressment of U.S. sailors from American merchant ships, escalated into a general clamoring for war.

In preparation for further military action against the British, which ensued in 1812 and so named the War of 1812, numerous fortifications, including Fort Trumbull, were upgraded as part of the Second System of Coastal Defenses (1807 to 1814). This period saw the demolition of the previous Fort Trumbull and construction of an entirely new structure, circa 1812. Few sources comment on the design of this fort. Caulkins claimed that the original fort was entirely leveled and rebuilt from the foundation up, noting that it was "far superior to the former structure," but that imperfect preparation of the surface resulted in erosion and falling rocks.[15]

Based on the Plan and Profile of Fort Trumbull (circa 1812), the irregularly-shaped, five-sided fortress has sides measuring approximately 200', 80', 240', 170', and 100' long.[16] The fort has an entrance gateway on the northern side. There is a centrally-located structure, approximately 50' by 50', with a forecourt that appears to have a well and two small guard houses. The rest of the enclosed area of the fort is raised, with sections ramping up to the parapet. Two small buildings are located on the southern section of this raised area. The enclosed area outside the fort, to the north, contains four structures: a long, narrow structure to the east; a square building to its west (the Blockhouse [Building 42]); a rectangular building along the north wall; and another smaller rectangular structure to the west.

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[14] Albert E. Van Dusen, *The Public Records of the State of Connecticut, May 1797 - October 1799*, vol. 9 (Hartford, Connecticut: Connecticut State Library, 1953): p. 264-265.

[15] Caulkins, op. cit., p. 56.

[16] Map located at the National Archives, Record Group 77, Fortification File: Drawer 30, Sheet 2.

The rebuilt Fort Trumbull was apparently strong enough to protect New London Harbor throughout the War of 1812. A garrison was stationed there by 1813, and, although the British fleet lay outside the harbor throughout most of the war, New London was not attacked.

The Third System of American Coastal Defense, 1816-1860

Creation and Characteristics of the Third System

The lingering effects of defeat after the War of 1812 prompted Congress to establish, in 1816, a Board of Engineers (also known as the Fortifications Board) to examine the nation's defenses and to design an overall defensive strategy, particularly for coastal defense. Formed by George Graham, acting Secretar[17]y of War, the original Board consisted of representatives from the U.S. Army, the U.S. Navy, and a distinguished military engineer from France, first, Brevet Brigadier General Simon Bernard, later Captain J.D. Elliot, and yet later, Lieutenant Colonel Joseph G. Totten.

Prior to the formation of the Board, individual engineers had prepared designs and plans under close guidance of the Secretary of War. Thus, the Board's creation marked the first effort within the War Department "to coordinate planning, to determine project standards, or to supervise the actual construction" of defenses.[18] This coordinated plan was known as the Third System of coastal fortifications (following the First and Second Systems, from approximately 1794 to 1807 and 1807 to 1816, respectively).

In February of 1821, the Fortifications Board submitted its first complete report, which identified the preferred locations for bases, repair yards, and anchorages. The report also addressed the fortifications needed to guard such works, as well as key rivers and seaports. The Board declared its first priority to be the development of coastal fortifications in order "to secure a particular harbor or waterway against a hostile naval force".[19] A prioritized listing of 44 forts (plus assorted batteries and towers) was compiled and further divided into two categories: those "of the most urgent necessity", to be built in the initial phase of construction between 1818 and 1827 (primarily restoring or replacing older works near main harbors); or those of lesser urgency, to be built during two

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[17] John R. Weaver II, *A Legacy in Brick and Stone - American Coastal Defense Forts of the Third System, 1816-1867* (Kokomo, Indiana, 1997): p. 6-8.

[18] Emanuel Raymond Lewis, *Seacoast Fortifications of the United States - An Introductory History* (Annapolis, Maryland: Naval Institute Press, 1979): p. 37.

[19] Lewis, *Seacoast Fortifications of the United States*, p. 38.

subsequent construction phases, 1828 to 1837 and 1838 to 1847.[20] Fort Trumbull fell into the latter category. The estimated cost of the proposed Third System fortifications amounted to nearly 18 million dollars, with close to half being spent in the first construction phase alone. By mid-century, the program had expanded to include 115 "works" (i.e., forts, batteries, and towers).[21]

The Board believed the Third System works would be superior to the transient predecessors, which were usually erected hastily, with little forethought to design. In addition to being able to withstand a naval or land-based siege, these defenses were oriented to abide by several guiding principles: could remain virtually unmanned until needed in war; could be maintained by a smaller militia rather than a larger standing army; and would be non-aggressive in appearance and generally appealing to all.

The earlier Third System defenses were usually constructed either of a combination of earth and stone or of stone or brick, and were armed with smooth-bore cast-iron muzzle-loading cannon. Later examples tended to be of reinforced concrete, and accommodated more powerful rifled steel breech-loading guns. Masonry was the preferred building material, not only because of its resistance to erosion, but also for its heightened resistance to the impact of cannon fire. Most significant to design, however, were stone and brick, which "made possible the inclusion of the casemate emplacement as a universal feature of major works constructed during the post-1816 era".[22]

After Bernard's return to France in 1831, Totten assumed control of the board until 1864. Totten quickly became the authority in Third System fortifications, eventually contributing 56 years of expertise to design and construction of fortifications. Totten developed the "Totten Shutters," devices that protected gunners while firing cannon, permitting "the gun openings of the embrasures to be reduced in size without diminishing the scope of movement of the armament within".[23] Subsequently, a shift to incorporating more than one tier of armament throughout Third System works, combined with the forts' larger sizes in comparison to earlier systems, "resulted in the

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[20] Lewis, op. cit. loc. cit. and Weaver II, op. cit., p. 8-18 .

[21] Lewis, op. cit., loc. cit, and Weaver, op. cit., 10.

[22] Lewis, op. cit., 43.

[23] Boston Affiliates, *Comprehensive Report on the Historical Buildings Survey of Naval Underwater Systems Center Facilities at Newport, Rhode Island; New London, Connecticut; Fisher's Island, New York; and Seneca Lake, New York* (Northern Division, Naval Facilities Engineering Command: May 22, 1985): n.p.

greatest amassment of weapons ever achieved in harbor defense".[24] In recognition of his distinguished career, the Third System has also been referred to as the "Totten System."

By order of General Richard Delafield, major Third System construction terminated in 1867, as the nation's shores were believed to have been made adequately secure. By then, only 40 out of 115 targeted "works" were actually begun, and no Third System fortification ever received fire from a foreign enemy. Future operations at the coastal fortifications were strictly maintenance-oriented. By the end of the nineteenth century, the Third System was considered outdated. Nevertheless, "some of the most spectacular harbor defense structures to come out of any era in military architecture" can be attributed to the primary forts of the Third System of American Coastal Defense.[25]

Fort Trumbull Prior to Third System Construction

During the period of 1820 to 1838, records indicate that artillery companies occupied Fort Trumbull.[26] One company of artillery manned Fort Trumbull in 1821 and by the fall of 1829, two companies were billeted, but in barracks sufficient to accommodate only one unit.[27] Few, if any, improvements were made to the Fort during this time. Annual reports on fortifications by the Secretary of War indicate that no money had been spent on fort modifications since 1805, and that no work was performed at the fort between 1822 and 1837.[28] Subsequently, a recommendation was made to either enlarge the current quarters or erect a second barracks.[29] In October of 1830, C.M. Thruston, Captain of the 3rd Artillery, conducted a survey of the post and described three stone buildings ready for occupancy, as follow:

- A building 104' in length, 40' in width, and three stories high for officer's quarters; "contains 4 tenements, containing each 4 rooms, with kitchen, servants room, and cellar"

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[24] Lewis, op. cit., loc. cit.

[25] Lewis, op. cit., 42.

[26] O'Neil, op. cit., 8.

[27] Lowrie, ed., *American State Papers-Military Affairs*, vol. 2: p. 455-459.

[28] Lowrie, ed., *American State Papers-Military Affairs*, vol. 3: p. 248.

[29] Colonel William Lindsay to Colonel R. Jones, Adjutant General's Office, September 29, 1829, Record Group 92, Records of the Office of the Quartermaster General, National Archives, Washington, DC.

- A building 94' in length, 34' in width, and two stories high for the two companies; contains four rooms for the two companies, although "capable of quartering four with comfort"

- A third building, 64' in length, 24' in width, and two stories high for mess rooms, kitchens, and store rooms for each company; likewise contains four rooms "able to accommodate two companies in comfort if necessary".[30]

In a letter to Major General Jessup dated almost two weeks after Thruston's survey of the new quarters and barracks, William Lindsay claimed "the stone work has been admired as one of the best specimens of that sort of building in N[ew] England; that the soldier's barracks are the best I have ever seen in the United States . . .".[31]

The military property itself also grew during this period. On April 9, 1833, Lucretia M. Mitchell deeded 2.25 acres, 27 poles (one pole equals a square rod, or an area 16.5' by 16.5'), and 204 square links (one square link equals one-third square') to the United States for military purposes.[32] This land was immediately surrounding the fort.

In 1834, plans unfolded to demolish the earliest remaining building on the reservation, the stone blockhouse. Rendered "useless as an arm of defense," the structure occupied a site on the parade grounds desired for military drills. Ironically, however, an assistant in the Army Engineering Department misquoted his superior (who actually favored the razing) by stating he "...recommends its being repaired or torn down, the former he would prefer".[33] Thus, the mistake resulted in the structure's unintentional rescue.

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[30] Captain C.M. Thruston to Major General Jessup, October 2, 1830, Record Group 92, Records of the Office of the Quartermaster General, National Archives, Washington, DC.

[31] William Lindsay to Major General Jessup, Quartermaster General's Office, October 14, 1830, Record Group 92, Records of the Office of the Quartermaster General, National Archives, Washington, DC.

[32] U.S. War Department, *General Orders*, File Conn.-2.1, Drawing and Manuscript, October 3, 1906, Record Group 77, Fortification Map File, National Archives, Washington, DC.

[33] Susan Babbitt, "National Register of Historic Places Inventory Nomination Form - Fort Trumbull, Underwater Sound Laboratory," February 9, 1972, National Park Service.

Construction of the Third System and Extant Fort Trumbull

Fort Trumbull was not a top priority in the Third System, having been classified as a defense of lesser urgency, thus slated for later-phase construction. The first priority on New England's southern coast was the defense of Narragansett Bay in nearby Rhode Island. Nonetheless, the cities of New London and Groton along the banks of the Thames River were considered crucial to the security of the U.S. In the Fortification Board's 1821 report, Bernard envisioned that "the forts at New London [Forts Trumbull and Griswold] will secure to the largest vessels a safe and excellent anchorage at all seasons. As the Thames River never freezes, they protect a good station whence our navy can, at all times, keep good watch...over the navigation of Long Island Sound".[34]

In 1837, getting impatient for funding, Connecticut Congressmen Samuel Ingham and Elisha Haley demanded that measures be taken to repair the miserable condition of Fort Trumbull, as well as to address the state's lack of adequate coastal fortifications. Upon implementation of the "Act for Appropriations for Certain Forts in the United States" later that year, a sum of $50,000 was allocated to commence the work at New London.[35] At an estimated cost of $177,445, the new Fort Trumbull was to garrison 75 soldiers during peacetime and as many as 460 at the first sign of war.[36] Engineer Order Number 1, dated July 17, 1838, announced Captain George Cullum as the managing engineer of the construction project.[37]

Construction, which rendered the final and extant version of Fort Trumbull, began in 1839, during the third and final stage of Third System construction.[38] Work began with the razing of the previous fort, "the rugged ledges blasted away, and the site beautifully graded for the reception of the new fortress", but the blockhouse would be "retained through all changes..."[39] Although not intended to be grand in scale, the Third System version was to be equipped with "all the latest improvements in the science of defense and gunnery."[40]

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[34] Lowrie, ed., op. cit., vol. 2, p. 36.

[35] Lowrie, ed., *American State Papers-Military Affairs*, vol. 7: p. 766-767.

[36] Lowrie, ed., op. cit., vol. 2, p. 31.

[37] From "Plan of Fort Trumbull, Conn.", 1879, Record Group 77, National Archives, Washington DC.

[38] Weaver II, op. cit., p. 37.

[39] Caulkins, op. cit., p. 519, 652.

[40] U.S. War Department Surgeon General's Office, 1870, p. 22..

In a letter to Colonel Totten dated July 24, 1839, Captain Cullum requested that the rebuilding of Fort Trumbull proceed, so "that the Public grounds, Wharf, Magazine, Officers' Quarters within the Fort, Sutler's Shop, Carpenter's and Blacksmith's Shop, Stable, Post Adjutant's Office, and Blockhouse, [all] belonging to that Post, be transferred to the Engineer Department, and the use thereof, with their appurtenances, be placed at my disposal."[41] Table 1 portrays Cullum's proposed disposition of the extant structures in regard to building material and future use.

Table 1
Captain Cullum's Proposed Disposition of Extant Structures of Fort Trumbull, July, 1839

Building(s)	Description
Magazine	Casemate in the fort to be demolished with the fort (1812 version)
Officers' Quarters	Brick building within the fort to be used as offices for the Superintending Engineer Clerk, Overseer, Master Workman, etc.
Sutler's Shop, Carpenter's and Blacksmith's Shop, and Stable	All wooden buildings to be used as material store houses
Post Adjutant's Office	Wooden building to be moved to another location (not specified)
Block House	Stone building to be repaired
Officers' Quarters, Soldiers' Quarters, and Hospital	All stone buildings that were not wanted
Ordnance Store	Wooden building also not wanted
Source: Captain George W. Cullum, M.S. Engr., to Colonel Joseph G. Totten, July 24, 1839. Record Group 92, Records of the Office of the Quartermaster General. National Archives, Washington, DC.	

[41] Captain George W. Cullum to Colonel Joseph G. Totten, July 24, 1839, Record Group 92, Records of the Office of the Quartermaster General, National Archives, Washington, DC.

By 1840, according to the *Annual Report of the Chief of Engineers* of that year, portions of the old fort had been removed. In addition, while granite was being quarried on the site, the new exterior battery (on the southwestern side of the fort) was ready to receive armament. By 1845, progress included the following:

- Construction of stone, brick, and concrete casemates and walls
- Application of asphalt to the casemate arches
- Completion of both a gateway in the north portal and a large magazine
- Grading of the esplanade
- Removal of the ruins of the old fort.[42]

Constructed of granite from the Millstone Point Quarry in nearby Waterford, the cost of the new fort was not to exceed the revised $250,000 budget established by the Corps of Engineers. Italian immigrants, transported to New London by boat after arriving in New York City, comprised a portion of the labor force that erected the structure.[43]

Fort Trumbull was essentially complete by 1852.[44] Francis Manwaring Caulkins, the premier historian of New London in the nineteenth century, described Fort Trumbull as "a beautiful structure; simple, massive, and yet elegant in form and finish, a magnificent outpost to the town, and a fine object in the landscape".[45] Egyptian-Revival influences, following a common trend in mid-nineteenth-century architecture, were evident in the entrance to the Third System fortification.[46]

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[42] U.S. Army, *Annual Report of the Chief of Engineers (ARCE)*, House Document #2, 28th Congress (serial volume 463, 1840): 164; and U.S. Army, *Annual Report of the Chief of Engineers (ARCE)*, House Document #2, 29th Congress (serial volume 480, 1845): 244.

[43] U. S. Navy, *USN-USL Bulletin*, Navy Day edition, vol. 1, no. 20, 29 October 1948: n.p.; and Lyman, op. cit., p. 14.

[44] U.S. Army, *Annual Report of the Chief of Engineers (ARCE)*, House Document #1, 31st Congress (serial volume 595, 1851-52): 353.

[45] Caulkins, op. cit., p. 519.

[46] Babbitt, Susan. National Register of Historic Places Inventory—Nomination Form. Fort Trumbull, Underwater Sound Laboratory, February 9, 1972.

The fort was designed for water defense, with only minimal provisions to withstand envelopment by siege. The fort's 62 guns were to be concentrated along the river faces, and a detached caponier in the rear of the fort would provide land defense. Irregular in shape, three of its sides faced the Thames River and were equipped with bastions at their ends, while the other two sides faced landward. Two spiral stair towers gave access to the ramparts. The following narrative describes the intended design and armament capabilities of Third System Fort Trumbull, a capability that would not be fully realized until 1876 (when the northern exterior battery was finally completed):

> Each of the seacoast fronts was casemated for one tier of cannon with a second tier mounted *en barbette*. Center-pintled cannon were mounted atop each bastion, except the one furthest upstream. This bastion was designed for three fore-pintled cannon....The three fronts were designed for 14 seacoast cannon, and the barbette could mount another 28 guns. In addition to this armament, two flanking batteries outside the fort were designed for ten heavy cannon.
>
> The gorge walls were casemated to contain barracks areas, and were loopholed to provide forward small-arms fire on an attacker. Forward fire was also to be provided from a howitzer embrasure at the eastern end of the north gorge. Flanking fire was to be provided by howitzers mounted in the flanks of each bastion.[47]

The post was garrisoned at various intervals from the 1840s to the Civil War.[48] Table 2 provides a description of the garrison strength during this period.

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[47] Weaver II, op. cit., p. 65.

[48] Hare II, William E., "Fort Trumbull and Heritage Park: Some Considerations," *New London Landmarks*. Volume XV, No. 4 (Spring 1993): passim.

Table 2
Garrisons at Fort Trumbull, May 1836 to July 1861

Troops Withdrawn	Troops Reoccupied	Description of Garrison
May 23, 1836	June 17, 1842	Companies E and K, 2nd Artillery (4 officers and 88 enlisted men)
May 30, 1846	September 27, 1848	Company A, 3rd Artillery (3 officers and 25 enlisted men)
October 7, 1853	July 6, 1861	Company A, 3rd Artillery (3 officers and 25 enlisted men); Company H, 2nd Battalion, 14th Infantry; also a recruiting station

Sources:
"Historical Information Relating to Military Posts and Other Installations, 1700-1900: Fort Trumbull, Connecticut", 1984. National Archives Microfilm Publication M661, Roll 7.

"Fort Trumbull, Connecticut - Chronology, 1775-1911", 1927. Record Group 94, Records of the Adjutant General's Office, National Archives, Washington, DC.

According to correspondence in records of the Office of the Quartermaster General, by May of 1852, the reservation contained 11 buildings, ranging from living quarters inside and outside the fort to assorted storehouses and sheds. Table 3 contains a description of each building.

Captain Cullum transferred control of the fort to Captain George Dutton in January of 1855[49]. In March 1856, Totten received notice that Fort Trumbull, as a fortification of the Third System, "may be considered as finished," according to an informal inspection made the previous July by Dutton. By 1860, a total of $280,941 had been spent on the new fortification[50].

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[49] Captain George Dutton, Engineer, to Brigadier General Joseph G. Totten, Chief Engineer, March 15, 1856. Record Group 77, Records of the Office of the Chief of Engineers. National Archives, Washington, DC.

[50] "Plan of Fort Trumbull, Connecticut, as Drawn Under the Direction of Brevet Major General J.M. Brannan by 2nd Lieutenant David Price." 1879. Record Group 153, Records of the Judge Advocate General's Office. National Archives, Washington, DC.

Fort Trumbull in Civil War and Post-Bellum Periods, 1861-1890

War-Time Events

On April 19, 1861, just one week after the Confederate attack upon Fort Sumter, Mayor J.N. Harris of New London received instructions to station a company at Fort Trumbull.

Table 3
Buildings at Fort Trumbull, May 1852

Building	Description [a]
Officers' Quarters	Contained four sets of quarters, each with four rooms (two on each story) [Building 27].
Enlisted Men's Quarters	Contained four rooms used as quarters and kitchens for troops (in 1852, occupied by Company A, 3rd Artillery) [Building 13].
Casemate Quarters	Contained four large rooms for soldiers, a kitchen, and five small rooms for Officers' Quarters [Located in fort].
Hospital	Contained four rooms [Building 14].
Guard House	Measuring only 4.9 m by 7.3 m (16 ft by 24 ft), also contained a small upper reading room and a meeting room for courts martial.
"Very old barn of a building of one room"	Used as a storehouse by the Quartermaster and Assistant Commissary; also used as ordnance storehouse.
Sutler's Shop	Small building with a straw storage shed.
"Very dilapidated Carpenter's Shop"	Used for minor repairs; its small addition contained Laundress Quarters.
Gun shed	No description
Boat shed	No description
Stable	Contained two stalls.

Source: First Lieutenant E.G. Beckwith, 3rd Artillery, to Major General Thomas L. Jessup, Quartermaster General's Office, May 26, 1852. Record Group 92, Records of the Office of the Quartermaster General. National Archives, Washington, DC.

Note:
a. Modern building numbers are indicated in brackets, where applicable.

Harris responded by sending the City Guards of New London to occupy the post, which had last been garrisoned in 1853. Local townsfolk, however, believed that the U.S. Corps of Engineers was not taking necessary measures to transform both forts Trumbull and Griswold into adequate strongholds of defense. Later in the year, the 14th U.S. lnfantry and the 3rd U.S. Artillery regiments made Fort Trumbull their headquarters, training center, and holding area, and by February of 1862, the post met the desired garrison of 127 men.[51] By the close of 1862, the facility also operated as the recruiting center for all companies departing Connecticut.[52] This was the setting for a Mark Twain short story, published in 1882, entitled "A Curious Experience," which describes espionage activities at the fort during the war.

Because the Confederacy lacked a navy strong enough to conduct operations along the shores of New England, Fort Trumbull witnessed no action during the war and served solely as an organizational center for Union troops.[53] Tbe troops stationed at Fort Trumbull engaged in actions of other sorts, however, earning themselves an unfavorable reputation with both the local citizenry and the police. Activities such as peddling liquor to the soldiers at nearby Camp Thomas, soliciting prostitution, street fighting with each other and with civilians, tavern brawling, beatings and shootings were common, and induced fear in the townspeople. In the view of some citizens, Fort Trumbull "housed an unruly lot and...acted as an avenue for "deserters to crawl out of the army . . [and] for cripples to crawl in".[54] As the war progressed, cases of desertion and juvenile delinquency increased, and "the accounts of arrests and escapes [of soldiers at Fort Trumbull] became legend".[55]

One of the more extreme incidents occurred on Water Street in New London in September, 1862. In response to the death of a solider who had been drinking at an establishment owned by a John Lopez, more than 100 soldiers garrisoned at the Fort and "armed with swords, pistols, and axes attacked John Lopez's building reducing it to ruins in 30 minutes"[56] The fort's commanding officer

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[51] Decker, Robert Owen. *The Whaling City: A History of New London.* (Chester, Connecticut: Pequot Press, 1976): p. 123.

[52] Hare II, op. cit., loc. cit.

[53] O'Neil, op. cit., p. 14.

[54] Decker, op. cit., p. 123-125.

[55] Ibid.

[56] Ibid.

rushed to the scene and ordered the soldiers' return, but later that night, someone set fire to Lopez's property, destroying it and damaging or destroying several neighboring buildings.[57]

Post-War Demobilization

After the Civil War, the rapid demobilization of the military had a dramatic effect on American coastal defenses. By the mid-1870s, harbor defense construction had all but ceased, and U.S. coastal fortifications fell into disrepair, reducing the defensive strength of the nation in the early 1880s to its lowest point since 1812. At Fort Trumbull, there was a rapid and drastic decrease in detachments stationed at the fort after 1865 [58]. Correspondingly, despite revolutionary advances in heavy ordnance and coastal armaments throughout this period, the fort itself received little attention in terms of new armaments or improvements, with the exception of the northern exterior battery, envisioned by the Third System plan, which was ultimately completed 1876.

At the time of inspection by John Campbell of the Surgeon General's Office in December of 1870, several officers resided in "very comfortable casemates in the fort," while two companies of soldiers occupied barracks outside the fort. Campbell described the layout of Fort Trumbull as follows:

> In parallel lines at a short distance from the sally-port, and running west therefrom, lie the officers' quarters, the men's barracks, and the hospital, a space of not more than 50 feet separating the buildings. The officers' quarters consist of a block of four two-story buildings of granite, comfortable, and in good repair. The soldiers' quarters consist of one building of granite, one story, with kitchen and offices underneath, and one frame building, continuous with the other, which has just been converted from a quartermaster's storehouse to its present purpose. One company occupies each of the buildings. To the rear of these lies the hospital. Its main building, erected many years before the present fort, is a one-story granite building, with a central hall, on one side of which is the surgery, on the other a ward; beneath are a kitchen and mess-room, the fall of the ground making two clear stories in the rear. Toward the end of the [Civil] war two frame wings were affixed to the hospital, the eastern one of which is now used as a ward, while the western one has been lately converted into a quartermaster's and commissary storehouse.[59]

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[57] Ibid.

[58] Boston Affiliates, 1985, loc. cit.

[59] U.S. War Department Surgeon General's Office. "Fort Trumbull, New London, Connecticut - Report of Surgeon John Campbell, US Army." In *A Report on Barracks and Hospitals with Descriptions of Military Posts*. Circular No. 4 (December 5, 1870): p. 23.

By 1873, architectural drawings of the quartermaster buildings indicate that the four cottages previously housing the married soldiers were used as laundress quarters and as residences of the hospital steward and ordnance sergeants. The old frame barracks had likewise been converted into laundress quarters.[60]

By 1879, no guns had been mounted in the north exterior battery, which had been completed in 1876 at a cost of $45,000 with the intention of accommodating the most modern guns of the time. At that time, the south exterior battery held eight mounted guns typical of the Civil War period (six eight-" Rodman Guns and two 100-pound Parrott Guns), as well as four siege guns on platforms along the southern edge of the waterfront.[61]

Due to Fort Trumbull's location on a small jutting promontory (originally dubbed Mamacock by native Americans) into the Thames River, there was little room to expand onto adjacent lands. This topographic limitation resulted in "the quarters and other buildings [being] crowded into very uncomfortable proximity to each other".[62] However, by 1883, the reservation contained approximately 30 buildings, as described in Table 4.

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[60]"Quarter Master Buildings at Fort Trumbull." Plans of 19 buildings received from Colonel Rufus Ingalls in November 1873. Record Group 77, National Archives, Washington, DC.

[61] "Plan of Fort Trumbull, Connecticut, as Drawn Under the Direction of Brevet Major General J.M. Brannan by 2nd Lieutenant David Price." Record Group 77, National Archives, Washington, DC.

[62] U.S. War Department Surgeon General's Office. 1870, op. cit., p. 22.

Table 4
Buildings at Fort Trumbull, March 1883

Building(s) [a]	Building Material
Officers' Quarters	Stone
Commending Officer's and Adjutant's Offices	Frame and brick
Barracks Battery "A"	Stone
Berracks Bettery "B"	Frame
Post Hospital, Store Room, etc.	Stone and frame
Four Kitchens	Frame and brick
Quartermester's Store Room	Freme
Laundress Querters	Frame end brick
School, Library, and Court Martiel Rooms	Frame
Granary, Hey, and Store Loft	Frame
Coel House	Frame
Cerpenter, Blacksmith, and Peint Shops	Frame
Boet House	Frame
Wood Shed	Frame
Engineer House	Stone
Eight Casemetes	Not given
Beke House used es Kitchen, Casemate	Not given

Source: Lieutenent Jemes L. Wilson, 4th Artillery. *Extract from Annuel Report of Inspection of Public Buildings at Fort Trumbull, Connecticut (showing the number of buildings at Post, the meterial from which constructed, end the emount estimated for repairs of seme for the fiscel yeer 1883-84.* Merch 31, 1883.

Note:
a. Although not included in the inventory, querters for married soldiers end an edministration building were present at Fort Trumbull in the late nineteenth century (Photo documentation from Record Group 92, Records of the Office of the Querter Master Generel, Netional Archives, Weshington, DC). In addition, structures listed in previous inventories, such as the stable and blockhouse, are likewise not mentioned. Thus, it should be assumed thet Wilson's inventory was not all-inclusive.

In April of 1887, Lieutenant Colonel Houston described the fort's armaments during inspection as follows:

> The northern land front, through which the sally-port passes, is protected by a cover face arranged with a place of arms and positions for six barbette guns. There are 14 gun and eight flank casemates in the main work, all of them ready for their armament; there is also an embrasure for a howitzer in the east casemate of the north front.
>
> On the barbette there are 21 old frontpintle platforms with two inch pintles, which will mount no gun larger than a 32 pdr [pounder]. There are also (on the bastions) three old platforms for 32 pdrs [sic], for the old wooden carriages with pintle in the rear transom. The six platforms on the cover face are of the same class as the f.p. [frontpintled] platforms on the main work.

The next paragraph in Houston's report is identical to Campbell's 1870 description (cited above), except that it records the distance between the officer's quarters, barracks, and hospital as 80' rather than 50'. Houston's description also records the Fortification Board's plans for the modification of the two exterior batteries, reporting that the north battery had been completed, but that the south battery modification had not yet begun -- "the old one still remains, with six eight-" Rod[man] and two 100 pdr. [pounder] Parrott rifles mounted thereon". [63]

Various garrisons manned Fort Trumbull during the late nineteenth century. In December 31, 1880, five officers and 74 enlisted men of Companies G and M, 1st Artillery were garrisoned. Ten years later, the garrison consisted of five officers and 59 enlisted men of Headquarters and Company L, 2nd Artillery. In December of 1893, two officers and 18 enlisted men of Company I, 4th Artillery, were garrisoned.[64]

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[63] Lieutenant Colonel Houston. Manuscript attached to a May 1886 Chief of Engineers map of Fort Trumbull. Text revised April 1887. Record Group 77, Fortification File. National Archives, Washington, DC.

[64] "Fort Trumbull, Connecticut - Chronology, 1775-1911", 1927. Record Group 94, Records of the Adjutant General's Office, National Archives, Washington, DC., n.p.

The Endicott and Taft Periods (1890-1910)

American Seaboard "Defenseless"

In the 1870s and early 1880s, a flurry of advancement in foreign, mostly European, naval armaments, coupled with the rapid post-war decrease in U.S. expenditures on coastal defenses, led to increasing concern that American coastal defenses had become obsolete.[65] Advancements included the fabrication of large (10,000 tons) iron-hulled vessels, driven by steam engines (with auxiliary sails) and up to 400' in length. Critical advances in the design and production of heavy ordnance included the first large-scale use of steel for guns, the perfection of breechloading, the invention of disappearing gun emplacements, and the introduction of far more powerful and effective propellants (Lewis, 1979)[66]. With increased vessel size, foreign vessels could become platforms for heavy, rifled guns capable of delivering ordnance powerful enough to destroy coastal masonry fortifications. In fact, the British had mounted 16" caliber guns on some of their capital ships.[67]

Fears were heightened by the 1882 Chilean bombardment of Callao, Peru and the 1882 British bombardment of Alexandria, Egypt -- vivid examples of an undefended port's fate. In 1883, President Chester A. Arthur called Congressional attention to America's virtually useless coastal defenses and in 1884, Commanding General William Schofield described American seaboard cities as "perfectly defenseless".[68]

Armaments and Vessels of the Period

The major armaments of the period 1886 -1905 (also referred to as the Endicott Period, after Secretary of War William C. Endicott) consisted of steel, rifled guns of 8", 10", and 12" caliber, the largest of which had a useful range of seven to eight miles with a 1,100-pound projectile. When compared to the weaponry of the immediate post-Civil War period (cast-iron, smoothbore weapons that discharged round projectiles, the largest weighing only 434 pounds, at maximum ranges of 4.3 miles), the weapons of the Endicott Period could fire projectiles that were almost three times as

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[65] Lewis, Emanuel Raymond. *Seacoast Fortifications of the United States - An Introductory History*. Annapolis, Maryland; Naval Institute Press, 1979, p. 75.

[66] Ibid.

[67] Greger, Rene, *Battleships of the World*, (Naval Institute Press, 1997): p. 11.

[68] Millett and Maslowski, *For the Common Defense*, (New York: Free Press, 1984): p. 253.

heavy, to ranges two to three times as great. These guns also had dramatically increased armor-penetration ability and accuracy.[69]

In terms of vessels, capital ships in the 1860s were generally small (6,500 tons), lightly armored (iron plating over wood), wind-powered (with auxiliary steam engines), and about 300' maximum in length. The pre-Civil War smoothbore cannon, when fired from the pitching, unsteady decks of these ships, proved to be of little threat to the masonry of coastal fortifications. The heavier, larger, more stable ships of the Endicott period, combined with the development of the rifled naval cannon and the high-explosive shell during the late 1850s and 1860s, began to prove a threat to defensive masonry fortifications such as Fort Trumbull.

The Endicott Report and the Build Up of Coastal Defenses

To address concerns over the status of U.S. coastal defenses, Congress, by means of the Fortifications Appropriations Act of March 1885, directed President Grover Cleveland to assemble a special board, headed by his first Secretary of War, William C. Endicott, to review the nation's entire coastal defense system. Known as the Endicott Board, the joint Army-Navy-civilian group was charged with submitting recommendations for improving the nation's coastal defenses. This was the first comprehensive examination of U.S. coastal defenses since the time of Bernard and the Third System almost 70 years before.

The Endicott Board's report first identified three general goals of an improved U.S. coastal defense system:

- Defense of coastal commercial ports
- Protection of foreign trade by ensuring safe anchorage for foreign trading vessels
- Protection of specific strategic positions from capture by an enemy with superior naval vessels in such areas as Long Island Sound, the Florida Straits, and the Chesapeake Bay region[70]

To meet these goals, early in 1886, the Endicott Board outlined an ambitious program of structural reinforcements, replacement, and new construction at 26 coastal and three Great Lakes sites. In order to protect coastal areas from long-range naval gunnery, the report stressed the forward deployment of defenses in such areas as Long Island Sound and the Delaware and Chesapeake Bays.

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[69] Lewis, op. cit., loc. cit.

[70] H. Exec. Doc. 49, 49th Cong. 1st Sess. 1886.

Other sites were to be abandoned or reduced in importance due to their now-indefensible or obsolete locations.[71]

The Endicott Report [72] further called for a vast number of new armaments -- 1,300 guns and mortars of 8" caliber and larger -- many of which were to be protected by armored turrets and casemates. The report also called for the deployment of floating batteries, torpedo boats, and underwater mines to augment the land-based defenses.[73]

The building program sparked by the Endicott Report featured widely separated batteries which would present the aggressor with numerous concealed targets and increase the number of directions of incoming ordnance, thereby reducing the enemy's ability to engage in evasive maneuvers. The separation of batteries required the acquisition of numerous new military reservations to provide space for the dispersed placement of weapons. Frequently, these weapons were placed in a more seaward location or within batteries adjacent to the Third System forts, most of which were structurally unable to accommodate the new weaponry.[74]

Over time, the unexpectedly high performance of the new armaments (which were also higher in cost and took longer to manufacture than previous weaponry) resulted in a reduction of the number of weapons ultimately required. Furthermore, the ambitious construction program recommended by the Endicott Report, which was begun in the early 1890s, was whittled down by Congress and the Army over the next 15 years. Consequently, fewer than 700 modern, large-caliber guns and mortars were installed.[75]

Long Island Sound and Fort Trumbull

In the 1880s and 1890s, Long Island Sound and its harbors were of strategic and commercial importance to New York City and the New England region. Four-fifths of the commercial trade between New York and New England passed through the Sound. Its protected waters made it an

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[71] Lewis, 1979. p. 76-77.

[72] H. Exec. Doc. 49, 49th Cong. 1st Sess. 1886.

[73] Lewis, op. cit. p.78.

[74] Lewis, op. cit. p.79.

[75] Lewis, op. cit. p.83.

attractive anchorage for ships during bad weather.[76] To improve the defensive status of the Sound and the eastern approach to New York City, the Board recommended that Gardiners Bay and Plum, Gull, and Fishers Islands be fortified. Fortifications at Gardiners Bay would deny the use of this well protected harbor by opposing forces. Coastal defenses placed on Plum, Gull, and Fishers Islands, located near the mouth of the Sound where it constricts to 3.5 miles, an area often referred to as "the Race", would command the entrance to the Sound.

The Endicott report also outlined the number of guns that should be added to each coastal fortification and the order in which cities should be fortified. New London was listed fifteenth nationally, behind more important ports such as New York, San Francisco, Portland, and Boston. The following additional armaments were recommended to augment Fort Trumbull's obsolete inventory of weaponry: four 12", 50-ton guns; four 10", 27-ton guns; barbette batteries; submarine [underwater] mines; 18 torpedo boats. The larger armaments would permit the fort to engage enemy forces at distances of up to five miles into Long Island Sound, providing sufficient protection for the Navy's coaling station at Groton. The estimated cost to supply and install the additional armaments at Fort Trumbull was approximately 2.3 million dollars.[77] Although a few modern guns and mortars were added to Fort Trumbull's roster of armament, the recommended improvements were never actually made at New London.

The 1906 Taft Board Report

As part of his plan to further advance the Navy's role as a powerful force for engaging the enemy on the high seas and projecting force abroad, President Theodore Roosevelt sought to reduce the Navy's responsibility for coastal defense by bolstering land-based defenses. In 1905, Roosevelt convened a group similar to the Endicott Board, this one headed by Secretary of War William Howard Taft, the purpose of which was to review and update the earlier board's program.

Although the Taft Board Report[78] generally embraced the spirit of the Endicott Report, its recommendations reflected a variety of changes/improvements in coastal and naval weaponry over the previous 20 years, which included searchlights at harbor entrances, electrification of harbor defenses (e.g., mines), longer-range and more reliable communications, powered ammunition handling, and markedly increased accuracy of guns. The awareness of changes in technology is most evident in the Taft Board's suggestions for positioning new fortifications. Unlike the Endicott Report, which recommended that harbors of some cities be fortified, the Taft Report, appreciating

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[76] H. Exec. Doc. 49, 49th Cong. 1st Sess. 1886.

[77] H. Exec. Doc. 49, 49th Cong. 1st Sess. 1886.

[78] S. Doc. 248, 59th Cong. 1st Sess., 1906.

the increased range and accuracy of the latest naval guns, recommended instead that the mouths of major estuaries and sounds be fortified. From these more forward positions, United States coastal defense forces could engage an enemy before it could threaten the nation's cities and harbors.

As did the Endicott Report, the Taft Report listed, in order of urgency, the geographic areas needing additional protection. The first location listed was the mouth of the Chesapeake Bay, the waterborne approach to Washington. The second area of importance was the mouth of eastern Long Island Sound, the eastern approach to New York City. Of the approximately 50 million dollars the Taft Report recommended for upgrading the nation's coastal defenses, five million, or roughly 10 percent, were earmarked for upgrading the defenses of eastern Long Island Sound.

The fortification of eastern Long Island Sound had already begun in 1898 with the commencement of construction of Fort Terry on Plum Island, Fort Michie on Little Gull Island, and Fort H.G. Wright on Fishers Island. Initially no more than single batteries, these coastal forts completely commanded the entrance to Long Island Sound. The Sound is only 3.5 miles wide at the location of these islands, and the 10" guns initially installed at these forts would have had an effective range of over 7 miles, permitting the forts to use overlapping fire to deny entry to the area. The Taft Board proposed enlarging the fortifications of these islands and equipping them with the largest guns available, creating an even more formidable obstacle to any opposing force.

This change in defense philosophy directly affected New London. In essence, the Taft Report sealed the fate of Fort Trumbull with the statement that "the growth of the country, the improvements in ordnance, the building of a navy and matters of policy, during the past twenty years, have brought about a rearrangement of and additions to the Endicott Board, and rendered [certain fortifications] therein of minor importance. The ports and harbors that have been added [for defense], under the authority of Congress, are at the eastern entrance to Long Island Sound, which renders the fortifications for New London and New Haven useless.".[79] Upon completion of the outer forts, Fort Trumbull was downgraded from a defensive installation with sub-posts to a supply sub-post of Fort H.G. Wright on Fisher's Island.

Activities and Changes at Fort Trumbull

During the late 1800s, New London was still the third most important commercial port in Connecticut, after New Haven and Bridgeport. Its moderately-sized harbor was a deep-water port that was almost always ice-free. In 1884, New London was home port to some 250 sailing vessels,

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[79] S. Doc. 248, 59th Cong. 1st Sess., 1906.

including steamers, canal boats, barges, and fishing vessels.[80] New London's defenses remained Fort Trumbull and Fort Griswold, located on the western and eastern side of the river respectively, although Fort Griswold was unmanned and unarmed.

The only new structure added to the fort during the Endicott-Taft period was a bath house for enlisted men, constructed in 1893 north of the fort along the shore of the river .[81] Armaments at the fort were augmented in the 1890s, as shown in Table 5. However, this additional weaponry was nowhere near the complement proposed by the Endicott Board, was for the most part obsolete, and paled in comparison to the power of the armaments of the outer defensive islands and potential opposing naval forces. In fact, the fort was beginning to fall into disrepair. In 1892, *Harpers Weekly* referred to Fort Trumbull as "an obsolete granite affair..".[82] The fort seemed to serve civil as much as military functions. In the evening, the fort would fire a salvo to alert the ships in the harbor to turn on their lights, and on Sundays civilians were allowed to stroll about and picnic on the grounds of the installation.[83]

The fort saw a brief period of military activity in 1898, prior to and during the Spanish-American War, when New London Harbor was a point of embarkation for troops and arms. This caused concern that the harbor might be attacked, which became moot when Spanish fleets were destroyed in Manila Bay on May 1, 1898, and Santiago de Cuba on July 3, 1898.[84]

In 1900, the fort and its surrounding grounds consisted of 2.9 hectares (7.2 acres) and 39 buildings/structures, with a complement of five officers and 59 men. The individual casemates of Fort Trumbull itself were used as officers' quarters, a library, an exchange, and a gymnasium.

In 1904, the Quartermaster General reported that Fort Trumbull contained four officers' quarters, two 60-man barracks, three non-commissioned officers' quarters, a four-bed hospital, and 16 other support buildings (sheds, stables etc.). Fort Trumbull had already been electrified, and

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[80] Treasury Department, Annual Report Chief of Bureau Statistics, (1884) Cited in TAMS, 1999.

[81] U.S. Army, Department of the East, United States Adjutants Office. *Roster of Troops, 1907.* (Washington : GPO, 1907): passim.

[82] Lathrop, G.P. "Defense of New York; The Outer Line and New London," *Harpers Weekly*, vol. 35 (Nov. 14, 1891): p. 894-95.

[83] Decker, op. cit., p. 123-125.

[84] Decker, op. cit., p. 135.

received potable water from the town via 4" and 6" water mains. The sewage system, dating to 1899 when the New London Board of Sewer Commissioners was issued a revocable license to "construct and maintain a sewer across the reservation,"[85] consisted of pipes that drained into the Thames River.[86]

When Fort Trumbull became a sub-post to Fort H.G. Wright in 1907, the installation was reduced to providing housing for a mine company and a transportation detachment that ferried freight consigned to the forts that made up Artillery District New London, which were Forts Michie, Fisher, and Mansfield.[87] The fort's garrison strength continued to decline. Whereas there were two companies of coastal artillery garrisoned at the fort in 1901 and 1902, the garrison dropped to one company of artillery from 1903 to 1906, although the fort also supplied 30-man detachments to one or two sub-posts during this time (Fort H.G. Wright, Mansfield, or Michie). In 1907, Fort Trumbull was reassigned as a sub-post of Fort Wright, which was better armed and positioned to defend eastern Long Island Sound. Fort Trumbull then served as a supply depot for the forts in eastern Long Island Sound from 1907-1910, with a garrison of one mine company (awaiting suitable permanent barracks at Fort Wright) and one 12-man transportation detachment.[88]

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[85] "Quarter Master Buildings at Fort Trumbull." Plans of 19 buildings received from Colonel Rufus Ingalls in November 1873. Record Group 92, Records of the Office of Quartermaster General. National Archives, Washington, DC.

[86] Quartermaster General, "Fort Trumbull, Connecticut." in Outline Description of Military Posts and Reservations in the United States of America and Alaska (Washington D.C. GPO: 1904): p. 499.

[87] U.S. Army, Department of the East, United States Adjutants Office. *Roster of Troops 1907*: p. 12-13.

[88] U.S. Army, Department of the East, United States Adjutants Office. *Roster of Troops 1901-1909*. passim.

Table 5
Fort Trumbull's Armaments, 1892 to 1901

1892 Armaments	1896 Armaments	1901 Armaments
Four 8-in Rodman Guns; Three 10-in mounted mortars; Four 8-in mounted mortars; and Two 100 pound Parrott Guns	One 8-in Rodman Gun; Three 10-in siege mortars; Four 8-in siege mortars; Two 100-pound Parrott Guns; One Coehorn mortar; and Two 8-in converted Rifles.	Four 15-in Rodman guns; Four 8-in siege mortars; Two 4.5-in siege rifles; Three 10-in siege mortars; Two 100-pound Parrott Guns; One Coehorn mortar; Two 8-in converted Rifles; One 10-in seacoast mortar; and One 3.6-in rifled field mortar

Sources:
"Fort Trumbull, New London Harbor, Connecticut". Sketch Showing Armament, April 1, 1892.

U.S. Army Corps of Engineers, 1897. "Defenses of Long Island Sound. Fort Trumbull. New London Harbor, Connecticut". Sketch to accompany Armament Report of 1896.

U.S. Army Corps of Engineers, 1901. "Defenses of Long island Sound. Fort Trumbull, New London Harbor, Connecticut". Sketch to Accompany Armament Report of 1901.

Notes:
In 1892, All armaments were located in the southern exterior battery, which was located closest to the Sound. (Map 249-6-8)

In 1896, the majority of armaments was located in the southern exterior battery, although the single Rodman gun was located in the northern battery.

In 1901, the majority of armaments was located in the southern exterior battery. The Rodman gun was located in the northern battery, the one 10" seacoast mortar and 3.6-rifled field mortar remained east of the southern battery along the shoreline, and the two 4.5" siege rifles and several 12-pound brass reveille guns were located just west of the northern exterior battery. The Coehorn mortar was located just north of the fort and west of the northern battery.

World War I, 1910-1920

From Revenue Cutter Service School to U.S. Coast Guard Academy

On July 1, 1910, the War Department leased Fort Trumbull to the Treasury Department for five years for the sum of one dollar, and the Revenue Cutter Service School of Instruction moved to the fort that same year. During the early part of the twentieth century, the Treasury Department's Revenue Cutter Service, the forerunner of the Coast Guard, had operated its School of Instruction aboard the *Ithaska*, a cutter moored in Arundel Cove, Maryland. By 1908, however, the physical limitations

of a shipboard school and an expanding enrollment led the school's director, Captain Jacobs, to begin searching for a new location. Fortuitously, the economic depression of 1908 had prompted the Taft Administration to reduce government expense by reallocating costly surplus facilities to needy organizations. Jacobs searched for available federal properties that could be inexpensively converted to a Revenue Cutter School, and found Fort Trumbull, whose usefulness as a coastal defense was now deemed minimal.[89] Jacobs successfully requested that Fort Trumbull be turned over to his school.

Upon arrival at the fort in 1910, many of the cadets were shocked at its state of disrepair. The fort lacked proper dormitory space, cooking ranges, adequate docking, classrooms, a gym, indoor plumbing, and other facilities, including instructional resources. Cadets on leave in late September were told to stay home for a few extra weeks so that repairs could be made to the fort. When the cadets finally reported, alterations were still not finished, forcing the cadets to live aboard the *Ithaska* until December of 1910.[90]

During the first few years of the school's occupation of the fort, cadet life continued to be hampered by the inadequacy of the facilities, particularly bathing and classroom facilities. It was not until 1916 that a communal bathroom was added in the basement of the cadets' barracks. Rear Admiral (RADM) Earl G. Rose described the fort in 1910 as "tall in weeds, a stony and forlorn looking place, devoid of creature comforts".[91] In spite of this, the first class of the School of Instruction graduated on December 10, 1910, at Fort Trumbull.

On February 15, 1911, the Fort Trumbull military reservation was leased under new terms to the Treasury Department, with the War Department reserving certain docking privileges[92] seemingly securing a permanent site for the school. However, in 1912, the Taft Administration again sought to curtail federal expenditures, and the Civil Sundry Bill of 1913 barred the appointment of additional Cutter Service cadets without specific permission from Congress. This limitation reduced the student body to five in 1914, and the school was in imminent danger of closing. Despite the school's dire straits, it was renamed the Revenue Cutter Service Academy that year.

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[89] Johnson, Paul H. *"The Academy at Fort Trumbull Part One and Two" The United States Coast Guard Academy Alumni Association Bulletin*, 1970, p. 5.

[90] Ibid., p. 5-7.

[91] Ibid., p.8.

[92] 36 Stat. 906.

Relief for the Academy came in 1915, following the outbreak of World War I (WWI) and the imminent involvement of the United States.[93] As the nation reacted to the war in Europe, more Cutter Service officers were needed to help inspect ships, protect the coast, and ensure the tenuous neutrality of American waters. Congress and President Woodrow Wilson acted to bolster the status of the Cutter Service. On July 1, 1915, Congress approved the transfer of Fort Trumbull to the Treasury Department.[94] The President then ordered the merging of the Life Saving Service and Revenue Cutter Service, creating the modern Coast Guard. The Revenue Cutter Service Academy was again renamed, this time as the U.S. Coast Guard Academy.[95] In the next few years the need for trained officers and sailors would transform Fort Trumbull from an obscure academic institution to a major military training facility.

Activities at Fort Trumbull During World War I

While the nation prepared for the possibility of war, life at Fort Trumbull continued almost undisturbed. However, on April 6, 1917, the serenity of life at Fort Trumbull was shattered with the news that the United States had actively entered the war. The dozen or so cadets who were currently enrolled at the Coast Guard Academy were put to work helping to train the several hundred new wartime recruits. Many of the recruits trained at Fort Trumbull saw duty as sailors aboard escort ships between Gibraltar and England.[96]

Despite training thousands of sailors for service in WWI, Fort Trumbull witnessed direct action only once in the war. On the morning of April 6, a group of officers, cadets, and enlisted men from Fort Trumbull rowed to a state pier to engage in a military maneuver. The German cargo submarine *Deutschland* was moored at the pier. At 3 a.m., the official start time of the war, the men captured several over-age German seamen aboard the submarine. The submarine, however, was a civilian vessel, and the Americans were subsequently forced to release the Germans.[97]

In addition to training Coast Guard cadets, the Navy also made use of Fort Trumbull as an experimental torpedo-testing and submarine-detection facility during the war. Personnel at the

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[93] Johnson, op. cit., p. 13.

[94] 36 Stat. 906.

[95] Johnson, op. cit., p. 16.

[96] Johnson, op. cit., p. 18.

[97] Decker, op. cit., p. 135.

installation worked on the problem of submarine detection through the use of hydrophones and towed fish arrays.[98] Begun in early 1917, antisubmarine research at Fort Trumbull was conducted by several prominent scientists from the National Academy of Sciences. Funding for the project originally came from academic and scientific organizations. In October of 1917, Secretary of the Navy Franklin D. Roosevelt realized the potential offensive capabilities of the submarine, and was instrumental in transferring the sum of $300,000 to fund the project. On October 12, the Navy took control of the research project and designated it as the Navy Experimental Station New London.[99]

The research and experiments at the station included use of Navy planes and dirigibles. By late 1918, assets of the research facility included numerous buildings, test facilities, three submarine chasers, a destroyer, and more than 700 enlisted men. The Naval Research Lab at New London was to continue operating for many years to come, and many inventions and devices in anti- and pro-submarine warfare would be designed, tested, and patented in the decades to follow.

Physical Changes to the Fort

The most significant wartime change to the Academy was the erection of numerous buildings to meet the demands of wartime activities. Most notable of the construction activity in this period were the following:

- removal of the southern battery and the construction of a 50 by 175' barracks for the housing of 400 men
- construction of an 60 by 185', u-shaped barracks for 240 men located just north of the 400-man barracks (the site of which was originally an officers' garden)
- construction of a telephone school measuring 25 by 100' located by the pier
- construction of 16 other buildings comprising the new Navy Experimental Station, located south of the intersection of Trumbull and East Streets.[100]

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[98] Merrill, John. *Fort Trumbull and the Submarine: the Submarine brings New Purpose to a Mid-19th Century Fort* (Self-published, 1994): p. 6-10.

[99] Ibid., p. 6-7.

[100] U.S. Coast and Geodetic Survey. New London Harbor and Entrance to Thames River, Conn. 1884, New London Harbor and Naval Station, 1919. Copy in Connecticut State Library, Hartford.

By 1919, the post, including the naval research facilities, consisted of some 68 buildings, used by both Navy and Coast Guard personnel.[101] The shore of the South Cove contained a seaplane service facility, and a small test facility was located on Dove Point.

From 1910 through 1941, officers of the Coast Guard Academy and Receiving Station were housed in Stone Row (Building 27). From 1910 to 1920, Harder Hall served as cadet quarters and a drill hall (dorms and classrooms). Rooms in the barracks had one window each, housed two cadets, and contained beds, desks, and a knotted rope which was to be employed as a fire escape.

Prohibition to World War II (1920-1939)

With the signing of the Armistice on November 11, 1918, the different branches of the armed forces began a general scaling-down of men and materiel. The U.S. Coast Guard, however, was preparing to fight another war, the Rum War. The Rum War was the intended defense of American ports and coasts against the illegal smuggling of alcohol during Prohibition (1920 to 1933). To combat smuggling along the sizable American coastline, the Coast Guard recognized that the service would have to significantly increase its ranks. Fort Trumbull, with its leftover WWI barracks, was ready to train and house the expanded corps of cadets, future officers who would serve aboard the many destroyers and patrol boats assigned to chase smugglers.[102]

A three-story barracks was hastily constructed adjacent to the parade grounds circa 1920. This new building made possible the use of the prefabricated 1917-vintage buildings as classroom and living quarters for cadets. When the old cadet barracks were vacated, that space was converted to a library containing 500 volumes. The library's architecture was enhanced with the installation of a double curved staircase and wrought iron railings approaching the main entrance.[103] At around the same time, a large new T-shaped dock measuring approximately 420 by 24' was constructed.

In 1925, the old Army administration building was removed, allowing for the enlargement of the parade ground. The remaining portion of Building 14, originally constructed in 1860 and used as an office building and general storeroom when the Academy first opened at Fort Trumbull, had

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[101] Johnson, op. cit., p. 17.

[102] Johnson, op. cit., p. 9-11.

[103] Ibid.

become a barracks by 1928. Another part of the building, torn down, contained a coal bunker and boiler which presumably supplied heat to other buildings at the fort.[104]

Relocation of The Coast Guard Academy and Coast Guard Reorganization

Since its original occupancy in 1910, the limitations of the Fort Trumbull facility had always been a source of annoyance to the U.S. Coast Guard Academy. In the late 1920s, with an expanding cadet class and an increasing number of recruits for the Rum War, the problems of having a school in a fort became more acute; classes and labs were scattered haphazardly throughout the site, and many buildings were in poor condition. Academy officials began to look for a new site.

In August of 1929, the city of New London presented to the Treasury Department a deed for 40 acres of land, comprised of two parcels from the Allyn and Payne Street Estates, and the Department conditionally accepted it. Formal acceptance was completed on July 31, 1930, for $100,000. On September 20, 1932, the Academy relocated from Fort Trumbull to its new and present-day site.[105] It should be noted that a year earlier, in 1931, the Academy introduced a four-year curriculum, which has continued to this day. The Coast Guard, however, continued using Fort Trumbull as a training center for new recruits and for several other purposes.

Coast Guard reorganization in the 1930s brought Section Base Four to Fort Trumbull. Section Base Four was responsible for fleet operations, including search and rescue, and, during Prohibition, for patrols for rum-runners in the New London area. In 1938, the Coast Guard constructed a brick colonial revival building (Building 45) as its new headquarters for these operations. Building 45 contained offices, machine shops and radio facilities as well as quarters for personnel.[106]

As the 1930s ended, Coast Guard facilities at the fort also included enlisted personnel schools for training radio operators, yeomen, cooks and bakers, and pharmacy mates. The center for the Coast Guard Correspondence School was also on the reservation. Following the creation of the Maritime Service in 1936, Coast Guard personnel began training cadets of the Merchant Marine school, which was established at Fort Trumbull in that year.[107] In 1938, the Maritime Service built an extensive Officer Candidate School at the fort, which remained until 1946.

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[104] Boston Affiliates, 1985, loc. cit.

[105] Johnson, op. cit., p. 27.

[106] Boston Affiliates. 1985, loc. cit.

[107] Merrill, op. cit., p. 10.

By the end of 1938, the old pier, which had been extended in 1919, was identified on contemporary maps as the Coast Guard Wharf. In addition, two additional piers had been constructed south of the old pier.

World War II, 1939-1945

This section is based primarily on the publication *Fort Trumbull and the Submarine* by John Merrill (1994).

During World War II, Fort Trumbull and its environs were home to the U.S. Coast Guard, the U.S. Merchant Maritime Officers' School, and the Columbia University Division of War Research (CUDWR). The latter two were important components of the American war effort. Begun in 1938, the U.S. Maritime Commission Officers' Service School was one of the chief training centers for officers for the U.S. Merchant Marine fleet. With wartime demands for personnel at an all-time high, the school's enrollment peaked in 1943 at about 2,000, with a staff of 750. The School trained a total of approximately 15,000 men between 1938 and 1945. The CUDWR was a research and development lab for technological advances in sonar technology and submarine warfare, responsible for many important developments. Approximately 4,000 people a day worked, trained, and/or served at Fort Trumbull during the years 1941 to 1945.

At the start of World War II, England's dependence on trans-Atlantic convoys to import goods was threatened by German submarines (U-boats) traveling in "wolf packs." Wartime increases in the demand for goods and raw materials increased England's reliance on the convoys, many traveling east from Boston, Halifax, and New York. At the start of the war, many naval strategists believed that advancements in underwater detection equipment in the 1930s would lessen the offensive potential of the U-boat.[108] This, however, proved to be incorrect, and U-boat attacks on the convoys were disastrous. After the first 10 months of the war, the rate of Allied shipping losses was approaching twice that experienced in all of World War I.[109]

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[108] Ibid., p. 11.

[109] Ibid.

Attacks from U-boats often occurred without warning, for several reasons:

- the vast open area of ocean between North America and England made patrolling for submarines difficult
- the detection equipment of the time often failed to detect the presence of submerged submarines
- the response of a surface ship following visual detection of a submarine was often limited to taking evasive measures
- after an attack, a submarine could often trail behind a convoy undetected, to further harass shipping.

In addition to the submarine threat on the high seas, there were also numerous reports of submarine sightings and ship sinkings off the coast and near the harbors of many North American cities. Therefore, given England's dependence on trans-Atlantic shipping and the staggering losses the convoy ships were experiencing, it was soon recognized that research into anti-submarine warfare had to be initiated quickly.

The Establishment of the Underwater Sound Lab at Fort Trumbull

Vannevar Bush, a former detection researcher at the Naval Experimentation Station at Fort Trumbull during WWI and dean of the Massachusetts Institute of Technology (MIT) School of Engineering, was familiar with and understood the problems of submarine detection. Bush, then president of the Carnegie Institution of Washington, proposed to President Franklin D. Roosevelt in May of 1940 the concept of a National Defense Research Committee (NDRC). The committee would be charged with the overview, coordination, and supervision of scientific research for war purposes.[110] On June 15, 1940, President Roosevelt, under the National Defense Act of 1916, signed the letter of appointment for the NDRC, and two weeks later, on June 27, 1940, the NDRC was formed. The committee consisted of 12 members, with Bush selected as chairman.[111]

On October 16, 1940, Secretary of the Navy Frank Knox requested that the National Academy of Sciences (NAS) appoint a sub-committee to advise him on the scientific aspects of anti-submarine warfare. The group of NAS members assigned to address these issues was called the Navy Research Advisory Committee (NRAC). The Committee was led by two people from the California Institute

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[110] Ibid.

[111] Ibid.

of Technology (CalTech), Max Mason (Chairman) and R.A. Jewett, both of whom had been closely involved with setting up the Naval Experimental Station at Fort Trumbull during WWI. The NRAC formed a subcommittee headed by E.H. Colpitts, a recently-retired vice president of Bell Telephone Laboratories. The focus of the Colpitts Committee was to assess the current status of the submarine detection capabilities of the U.S..[112]

On January 1, 1941, the Colpitts Committee recommended immediate broad scientific and engineering investigations into the development of submarine-detection equipment and capabilities. The findings and recommendations of the Colpitts Committee were presented to the NRDC, which reviewed them in March of 1941 and recommended that laboratories be established under the auspices of several top universities.[113] At that time, submarine detection was still in its infancy and the methods highly theoretical, and many top scientists were employed by universities as researchers and professors. The establishment of research facilities under the auspices of academic institutions would allow these highly-skilled professionals and advanced students to assist in the development of new technological devices.

On April 10, 1941, Admiral S.M. Robinson, Chief of the Bureau of Ships (BUSHIPS), recommended that sponsorship be given to three universities -- Columbia, Harvard, and the University of California at Berkeley -- to proceed in the development of submarine detection devices. In addition, Robinson recommended that the laboratory be located near already-established submarine bases, preferably on the East Coast.[114]

Admiral Robinson's recommendations immediately facilitated meetings between the NDRC, the Navy, and Columbia University, which resulted in contracts between the Office of Emergency Management and the Columbia University Division of War Research, one lasting from April 1941 through August 1943 and the next from August 1943 to June 1945. Through these contracts, Columbia University scientists participated in the design and implementation of equipment to be used in warfare.[115]

In May 1941, potential locations on the East Coast of the United States were surveyed for the placement of a laboratory. The survey indicated that Fort Trumbull, which was close to the American Submarine School at Groton and located on a deep-water, ice-free port only two miles

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[112] Ibid., p. 12.

[113] Ibid.

[114] Ibid., p. 12-13.

[115] Ibid., p. 13.

from Long Island Sound, was a suitable location. Near the same time, BUSHIPS, the naval office in charge of the placement of bases, forwarded a memorandum (June 28, 1941) recommending that a naval facility be established at Fort Trumbull, and that the facility provide laboratory space, operating facilities, vessels and other support.[116] On July 12, 1941, the Chief of Naval Operations announced the establishment of the new laboratory, the Underwater Sound Laboratory (USL), at New London.[117]

In addition to the laboratory at New London, laboratories were also set up at the University of California at Berkeley, which maintained a facility at the U.S. Radio and Sound Laboratory in Point Loma, California, and at Harvard University. The director of the Harvard Underwater Sound Laboratory, Frederick V. Hunt, is credited with originating the acronym SONAR, which stands for sound navigation and ranging.[118]

Work at The Underwater Sound Laboratory

In 1941, the Underwater Sound Laboratory (USL) employed approximately 60 civilians, which increased to a high of approximately 330 in 1944 and then fell to a low of seven in June of 1945. The complement of Naval personnel assigned to Fort Trumbull was 36 officers and 263 enlisted men, of whom approximately 21 officers and 195 enlisted men comprised the crews of the Navy test vessels assigned to the laboratory. Approximately 20 test vessels, ranging in length from 18 to 205', were assigned to the lab. In addition, approximately 30 surface ships, 50 submarines, and numerous Navy airplanes and blimps took part in the various tests throughout the war.[119]

In the spring of 1944, activity was further increased at Fort Trumbull when a second group of approximately 15 was assigned there as a branch of a field station at Pearl Harbor, rendering technical assistance to the Commander, Submarine Forces U.S. Pacific Fleet (ComSubPac). The group served as a conduit for ideas and concerns of Pacific Fleet Submarine Commanders to

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[116] U.S. Navy Underwater Sound Laboratory. *An Engineering-Economic Study of Facilities at the U.S. Navy Underwater Sound Laboratory 3/1/54*. USL Report No. 232 Fort Trumbull, New London, Conn. 1959.

[117] Merrill, op. cit., p. 13-14.

[118] Merrill, op. cit., p. 15-16.

[119] Merrill, op. cit., p. 17.

laboratory personnel, thus allowing lab personnel first-hand knowledge of battle requirements and experiences.[120]

In October of 1944, the Navy decided that the Columbia and Harvard laboratories should be merged and should continue after the war under the auspices of the Navy. On March 1, 1945, the Naval Research Laboratory took over technical direction of the New London USL for BUSHIPS. In July of 1945, the sonar portion of Harvard's Laboratory development program was transferred to New London and merged with the work formerly undertaken by Columbia University.[121] On March 6, 1946, direction of the laboratory was transferred to the BUSHIPS, under whose jurisdiction it remained until 1960.

Projects representative of the work carried out at New London during World War II are the following:

- Expendable Radio Sonobuoy -- a floating hydrophone that transferred acoustic information to surface ships via a radio link
- Airdropped Expendable Radio Sonobuoy -- a floating hydrophone dropped and/or deployed by airborne means
- Surface Echo-Ranging Equipment -- equipment which halved the work time of sonar operators by automatically estimating the range (*i.e.,* distance) of sonar contact
- Small Patrol Craft Listening Equipment -- small, lightweight equipment able to be installed on smaller, more agile, ships
- general advancements and studies in submarine equipment.[122]

Sonobuoys

One of the devices recognized as a potential solution to the submarine menace was the sonobuoy. Sonobuoys are floating hydrophones that provide underwater listening capabilities via a return radio link to surface ships. Sonobuoys could be deployed by fast-moving ships traveling ahead or behind a convoy, thereby providing the convoy with the ability to detect the threat of submarines. With

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[120] Cited in TAMS, 1999.

[121] Ibid.

[122] Merrill, op. cit., p. 18-34.

increased warning time of a submarine's presence, a ship could take the appropriate evasive maneuvers. In addition, sonobuoys could be deployed to detect submarines trying to gain access to a harbor's entrance.

In 1941, the laboratory at New London became involved with the testing of two sonobuoy projects. The first project, started in September, was for the British Government under the auspices of NDRC. The results of the first test determined that while the electrical components and systems were excellent, the sonobuoys' limited range made them unacceptable for use on the open seas. However, this first design provided the basis for the development of later sonobuoys.[123]

A second sonobuoy project was started in December of 1941. This BUSHIPS project charged the laboratory, via the NDRC, to develop a hydrophone (sonobuoy) for use in harbor protection. The project was successful, resulting in the manufacture of numerous sonobuoys used in the defense of advance bases, primarily in the Pacific theater of war.[124]

Airdropped Expendable Sonobuoys

In February of 1942, the Navy requested that an airborne-deployed sonobuoy/hydrophone be designed that could be towed behind one of the many naval blimps that were currently patrolling the coasts of the United States. Use of these airborne devices was made possible by the recent development of the Magnetic Anomaly Detector (MAD), which enabled the operation to distinguish between a live submarine and a submerged wreck. Prior to the development of MAD, the use of such devices would have proved frustrating and impractical due to the high number of wrecks off the coasts of the United States.[125]

In March of 1942, an air-dropped sonobuoy test was conducted in the waters south of New London. The test, which included the submarine S-20 and the blimp K-5, marked the first time in history that an aircraft detected a completely-submerged submarine, and thus ushered in a new era in anti-submarine warfare.[126]

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[123] Merrill, op. cit., p. 20-21.

[124] Ibid.

[125] Merrill, op. cit., p. 21.

[126] Merrill, op. cit., p. 22.

Surface Craft Echo-Ranging Equipment

In conjunction with Harvard University, the New London Laboratory had an advisory role in determining how to reduce the physical size of echo-range locating equipment in order to save space and weight aboard already-cramped patrol boats.[127]

Small Patrol Craft Listening Equipment

In 1941, the New London Laboratory initiated work on provisioning small, highly-maneuverable vessels with listening equipment for use in detecting enemy submarines operating along or near the coast of the United States. The vessels to be equipped were small patrol craft stationed in and around the harbors of the United States.[128]

General Advances in Pro-Submarine Warfare

Pro-submarine developments included equipment, devices and methodologies used by submarines. At the beginning of World War II, nearly all of the work at New London was focused on anti-submarine warfare (equipment and methodology designed for use by surface vessels or aircraft to detect or counter submarines), prompted by Germany's relatively large U-boat fleet and its successful harassment of trans-Atlantic shipping. Germany's strategy directed a significant amount of resources toward the construction of a large submarine fleet. Ironically, at no time during World War II did Germany possess an aircraft carrier, a vessel which later proved to be integral to a naval's fleet actual strength.

By 1943, the submarine threat in the Atlantic had diminished, in part due to the advancements in technology gained at New London, and the Navy began to focus on the war in the Pacific. Japan, unlike Germany, had a relatively large surface and submarine fleet, and, in order to counter Japan's naval prowess, the U.S. Navy began to focus on pro-submarine developments.

In May, 1943, the laboratory began working on a device that would provide the approximate bearing of exploding depth charges. By 1943, the laboratory had completed a unit capable of indicating in which quadrant with respect to the submarine a depth charge had exploded, and whether it was above or below the boat's centerline. The laboratory engaged in numerous other pro-submarine developments, such as triangulation-listening-ranging; noise level monitors; depth-charge direction indicator; underwater telephone, single-ping echo ranging, and at least a dozen other projects. The

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[127] Merrill, op. cit., p. 29.

[128] Merrill, op. cit., p. 28.

pro-submarine effort at New London increased from 20 percent of total USL activity in August, 1943, to 85 percent of total activity in June, 1944.[129]

Construction of New Facilities at Fort Trumbull during World War II

Numerous structures were erected at Fort Trumbull during World War II to accommodate the Underwater Sound Laboratory, the flood of new recruits for the Maritime School, and the Coast Guard Station.

In 1943, three tracts of land immediately north and adjacent to the fort, with a combined area of 2.6 hectares (6.4 acres)[130] were purchased. The tracts included the entire block bounded by Walbach, East, and Smith Streets, and the land north of Chelsea Street and east of Smith Street to the waterfront. The tracts were utilized primarily by the Maritime Administration, which quickly erected numerous school facilities (dormitories, gymnasiums, etc.) to house and educate the almost 2,000 recruits enrolled there.

Among the major buildings constructed at Fort Trumbull to meet the many wartime needs were:

- Building 1 - built in 1940. A two-story building of semi-permanent construction that provided 36,946 square feet of space. It housed laboratories, administrative offices, and a centralized machine shop in the basement.

- Building 2 - built in 1941. A two-story building of semi-permanent construction that provided 3,294 square feet of space, utilized as a machine shop and recreational area.

- Building 24 - built in 1942. A building of semi-permanent construction that provided 18,226 square feet of space. Originally a mess hall, it was later converted into a laboratory.

- Building 11 - built in 1943. A two-story 9,665 square foot building used primarily as a garage.

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[129] Ibid., p. 29-30.

[130] Records of the U.S. Coast Guard. Record Group 26, Box 9, National Archives, Washington D.C.

- Building 28 (Maury Hall) - built in 1943 by the Coast Guard. A two-story building of permanent concrete construction that provided 7,900 square feet of space. It housed laboratories for experimentation and development of submarine radio and antennas.

- Building Furuseth 1 - built in 1943. A one-story building that provided 4,000 square feet of galley space and 10,000 square feet of mess hall space.

- Building John Leynard - built in 1943 by the Maritime Administration. A two-story building of semi-permanent construction that provided, 34,300 square feet of space, used as a recreation center;

- Building John Paul Jones - built in 1943. A four-story building of semi-permanent construction that provided 38,600 square feet of space.

- Building Moses Rodgers - built in 1943 by the Maritime Administration. A two-story building of semi-permanent construction that provided 10,800 square feet of administration space.

- Building Red Jacket - built in 1943 by the Maritime Administration. A three-story building that provided 12,600 square feet of dormitory space for cadets.

- Building Sovereign of the Seas - built in 1943 by the Maritime Administration. A three-story building that provided 39,320 square feet, utilized as a gymnasium and housing a swimming pool, and also used for certain maritime training exercises. In 1952, the pool was used as a sonar test facility. The second floor contained a boxing ring, a basketball court and dressing rooms and washrooms.

- Building Warrior (Firehouse) - built in 1943 by the Maritime Administration. A two-story structure used as a fire house and a boat shop.

- Fulton Power House - built in 1943 by the Maritime Administration. Located in the yard of Fort Trumbull, it provided 41,000 pounds of steam per hour.

- Red Cross Building - built in 1943 by the Maritime Administration. A three-story building of semi-permanent construction that provided 15,400 square feet of hospital space.[131]

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[131] U.S. Navy, Plot Plan: Government Reservation, Fort Trumbull, New London, Connecticut. *USN-USL Bulletin*. October 1954.

Post-World War II, 1946 -1950

The end of World War II resulted in a scaling-down of the United States' armed forces and military facilities, but Fort Trumbull would continue as an important educational and research post for decades. The post-war era from 1946 to 1950 at Fort Trumbull was marked by the switch from wartime to peacetime educational needs. The fort witnessed the departure of the Merchant Marine Academy and the arrival of the University of Connecticut. The Underwater Sound Lab (USL) came under the auspices of the Navy and was incorporated into the overall Naval Research Laboratory at New London. It would continue as one of the most important facilities in the United States for the research and development of numerous anti- and pro-submarine devices during the next 40 years.

In 1948, approximately 25 hectares (61 acres) of the military reservation at Fishers Island were transferred from the Department of the Army to the Navy for use as a field station of the New London Navy Research Laboratory (encompassing the USL). During the war, the Fishers Island site had been used by MIT as a Radiation Laboratory.

The University of Connecticut

The end of World War II ushered in a new era of higher education in America. Before World War II, a college education was a privilege reserved only for the wealthy, but with the passing of the GI Bill, a college education was made available to thousands of ex-military personnel. In 1946, universities and colleges around the country found themselves and their facilities overwhelmed with the ever-increasing numbers of new applicants.

The end of the war substantially reduced the number of maritime officers needed to serve in the United States' merchant fleet. Realizing this, the Maritime Administration discontinued the officers' school at Fort Trumbull and turned the facilities back to the Coast Guard. In 1946, the Governor of Connecticut, Raymond E. Baldwin, requested the use of the facility as a satellite campus for the University of Connecticut (Source I RG 26).[132] On June 16, 1946, the Coast Guard granted the State of Connecticut a five-year permit to use to the facilities as a satellite campus for some 2,000 new students (Source I RG 26).[133] The university employed some 70 professors, and remained active at Fort Trumbull until May 15, 1950. On July 1, 1950, the University of Connecticut discontinued use of the site, permanently turning over 5.7 hectares (14 acres) and 19 structures to the U.S. Navy Sound Laboratory.

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[132] Records of the U.S. Coast Guard. Record Group 26, Box 9. National Archives, Washington, DC.

[133] Ibid.

Naval Expansion of Warfare Research

On March 22, 1948, the Navy took ownership of the Coast Guard Reservation at Fort Trumbull. The Coast Guard retained several buildings and a pier in the northern portion of the base, and continues to use this facility as a patrol station to this day.

In the late 1940s, the Navy, recognizing the future need of the New London lab for research and development (R&D) of sonar and submarine equipment, began construction of several buildings, most of which served as storage or for infrastructure repair/maintenance. Examples of these buildings include the following:

- Building 12 - a salt water pumphouse built in 1949 to augment the fire-fighting system
- Building 15 - built in 1949 by the Underwater Sound Laboratory as a main gate guard house
- Building 19 - built in 1946. A two-story building that provided 1,900 square feet of shop space.
- Building 22 - built in 1948. A 130-square meter (1,400-square foot) concrete cinder block building originally built as a garage, converted and redesigned in 1952 to a hydrogen-furnace facility.
- Incinerator - built in 1949.

The Cold War and The Era of Nuclear Submarines, The 1950s

As the 1950s ushered in the Cold War, the United States and her adversaries recognized the potential of the submarine as both a conventional weapon and, later, a platform for delivering nuclear weapons. Launched in 1954, the first nuclear powered submarine, *Nautilus* SSN 571, ushered in a new age in submarine warfare. The performance capabilities of a nuclear submarine were unparalleled and far exceeded those of the older, World War II-era diesel-driven submarines. Nuclear submarines could stay submerged for as long as 60 days at a time, travel at deeper depths, and, more importantly, travel more quietly. Most of the research and development (R&D) projects at the Naval Research Laboratory in New London during the 1950s and 1960s were focused on advancements in submarine communications, detection, and navigation.

Sonar has often been referred to as the cornerstone of anti-submarine warfare. Many important post-war technical advances in submarine sonar development were made in the early 1950s. However, with the launching of the first nuclear submarine, it was recognized that a reappraisal of sonar capabilities was necessary. Nuclear submarines, with their increased speeds at greater depths, longer submersion times, and quieter engines, would prove elusive. In the 1950s, the laboratory also began a series of oceanographic studies to gather data for use in navigation and sound propagation.

Some representative developments and projects worked on at the New London Laboratory in the 1950s were the following:

- advances in sonar
- towed arrays
- AMOS (Acoustic, Meteorological, and Oceanic Study)
- Polaris and Extremely Low Frequency communication systems
- Electronic Warfare Support Measures (ESM)

Advances in Sonar

During the 1950s, two main objectives were pursued in sonar technology at New London:

- To increase detection ranges and make sonar performance less dependent upon the effects of the ocean's thermal structure. Abrupt changes in temperature inhibited sonar performance, thus allowing a submarine to lie undetected just below a thermal layer (thermocline).

- To decrease surface ship vulnerability to torpedo attack by providing improved torpedo detection and tracking.[134]

In the mid-1950s, the sonar detection ranges of surface ships were limited to the depth of an isothermal layer (a band or layer of water with approximately the same temperature). Sonar waves, which are sound waves emitted and received by a ship, are negatively affected by changes in water temperature and density. Two techniques developed by Naval personnel to address this problem were bottom bounce sonar and variable depth sonar.

Bottom bounce sonar. First theorized by physicist Thaddeus G. Bell at the New London Laboratory in the 1950s, bottom bounce sonar was a revolutionary sonar technique. Bell, through the use of data recorded earlier in the decade for deep water sound testing (propagation vs. loss studies) determined the optimal frequency at which a sonar beam would emit a sonar wave which, reflected

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[134] Merrill, op. cit., p. 32-64.

off the bottom of the ocean, would find a dependable transmission path to a target 20,000 yards away. The effect of bottom bounce is to return to the sending transducer sound energy that has been carried downward into the water column by the depression angle of the transmitted pulse or by refraction, enabling longer range transmission. Originally intended for use by surface ships to detect long-range torpedoes, bottom bounce sonar was later fitted onto torpedoes to be utilized as a homing device.[135]

Variable depth sonar. One device designed to operate within various isothermal layers was the Variable Depth Sonar (VDS), a transducer that was towed at depths of 500 to 600'. VDS offered some initial advancement in deep water submarine detection, but was still hampered somewhat by thermal gradients in the water column.[136]

Towed Arrays

Towed arrays were an important development in shipboard anti-submarine warfare. Developed in the early 1950s, arrays were originally used in commercial oil drilling operations to search for fossil fuel deposits in the deep waters off the continental shelves. Towed behind surface ships, arrays were hydrophones that located deposits by detecting changes in acoustic energy in an aquatic medium.[137]

The Navy soon realized that the concept of detecting underwater deposits could be adapted and applied to the detection of submerged objects such as submarines, and began conducting studies with towed arrays. In 1952, the Navy purchased hydrophonic equipment (two 92-meter [300'] sections of streamer hydrophones) from a Texas seismographic company and began conducting experiments at the Dodge Pond test facility in Niantic, Connecticut, and at sea from surface craft, with the results of the tests reported to personnel at New London.

The test results were encouraging, and towed arrays were soon adapted so that they could be used by submarines to detect other submarines and surface ships.[138]

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[135] Merrill, John and Wyld, Lionel D. *Meeting the Submarine Challenge: A short History of the Naval Underwater Systems Center*. United States Government Printing Office. 1997. p.65 ff.

[136] Ibid., p. 71.

[137] Ibid., p. 76-80.

[138] Ibid.

AMOS

AMOS (Acoustic, Meteorological and Oceanic Study) was a long-term effort to enhance the understanding of acoustic propagation in the sea by making extensive measurements in a wide variety of locations.

Between 1950 and 1955, Underwater Sound Laboratory (USL) personnel began conducting scientific and engineering studies in the Arctic Ocean. The original purpose of the work in the Arctic was to determine the propagation vs. loss ratio of sonar waves in and between different thermal gradients. The data gathered from these early AMOS studies was used to develop the bottom bounce sonar.[139]

Later in the decade, the capability of the nuclear submarine to operate beneath the polar icecaps increased the Navy's interest in the Arctic area north of 75 degrees North latitude. From 1958 to 1962, under the direction of Guy S. Harris, the USL fielded an extensive Arctic research program. The projects, designed to gather data on various underwater acoustic experiments, were conducted on Ice Stations Alpha, Charlie, T-3, and Arlis-2.

The Polaris Submarine and Extremely Low Frequency Communications

In the late 1950s, the Polaris submarine program required a continental United States-based communications facility that would be able to transmit a message to any submarine via satellite, regardless of depth or global position. To facilitate this mission, an intensive research program (PANGLOSS) was initiated, which focused on the transmission of radio waves at extremely low frequencies (ELF), 30 to 300 hertz (Hz), which, until that time had received very little attention. ELF waves are able to propagate through several hundred feet of seawater, enabling a submarine to receive messages while submerged.[140]

Beginning in the late 1950s, the Navy Undersea Sound Laboratory played a key role in the development of the Navy's ELF communication system. Some early laboratory projects included:

- transmitting antenna siting
- atmospheric noise measurement
- submarine receiving antenna development
- atmospheric submarine noise measurements[141]

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[139] Ibid., p. 64, 71 and Merrill, op. cit., p. 35.

[140] Merrill, op. cit., p. 51-55.

[141] Ibid., p. 54.

The Polaris experiments culminated with the New London research lab becoming the Navy's leader in the research, planning, implementation and enhancement of submarine ELF communications. The laboratory developed the first practical submarine receiving antenna for ELF, permitting reception at antenna depths much greater than previously possible. In 1963, the laboratory achieved an early milestone in the field by successfully communicating via very low frequency (VLF) with the USS *Seawolf* (SSN 575) operating in the North Atlantic.[142]

Electronic Warfare Support Measures (ESM)

Starting in the 1950s, New London Laboratory personnel were involved in the development, installation, and testing of submarine electronic support equipment. ESM is the practice of intercepting, identifying, analyzing and exploiting an adversary's electromagnetic signals for the purpose of supporting military operations. ESM equipment consists of periscopes and mast-mounted antennas, inboard radio receivers, and, in modern systems, computers to aid in identifying and analyzing signals.[143]

Antennas used on modern submarines include mast-mounted (retractable), buoyant cable, hull-mounted, and towed antennas. Almost all of the United States' submarine antennas have either been designed, have had design modifications made, or have patent origins at the New London Laboratory. Of particular note, the buoyant cable antenna used by all United States submarines was researched, developed, tested, and implemented by USL submarine antenna system personnel.[144]

Mast-mounted antennas. Prior to the end of World War II, in order to transmit via radio, a submarine had to surface and manually rig an antenna on the periscope shaft. In recognition of the potential danger and vulnerability of a submarine engaged in this process, work began in the mid-1940s at New London to enable a submarine to transmit radio messages while submerged. Much of the design and research of mast-mounted antennas was conducted at New London. Work on mast-mounted antennas included:

- Permanent mounted whip antennas
- Motor-driven retractable-whip antennas
- Streamlined sections of whip antennas with fairings
- Relocation of antenna tuners outboard of the hull and closer to the antennas

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[142] Ibid., p. 60.

[143] Ibid., p. 61-62.

[144] Ibid., p. 54.

- Development of multi-purpose antenna masts that could be raised or lowered from inside the submarine.[145]

Buoyant cable antennas. The buoyant cable antenna is a long, buoyant wire trailed from a submarine. The advantage of a buoyant cable antenna is that it enables a submarine to receive messages while submerged. The initial buoyant cable antennas allowed submarines, for the first time, to receive VLF transmissions while operating at depth.[146] James Tennyson, a career electromagnetic physicist at New London, was responsible for the introduction of the buoyant concept through his many initiatives and innovations.[147]

In 1954, a successful at-sea test was conducted with an experimental buoyant antenna on the submarine *Tusk* and the laboratory field station on Fishers Island, New York. Tennyson received patents for his work on buoyant antennas in 1962 and 1964.[148]

In August of 1958, Warner Adams and Richard Jones developed the first operational antenna system to feature a payout and retrievable reel system. This innovation enabled a submarine to deploy a 304 meter (1,000 foot) long cable antenna and subsequently to communicate at greater depths.[149]

By the end of the 1950s, the USL was manufacturing numerous fixed-length buoyant cable antennas. In 1959, the Submarine *Skate* (SSN 578), through the use of its buoyant cable antenna system, was the first to receive broadcasts under the Arctic ice cap during a North Pole transit. The following year the USS *Triton* maintained continuous radio reception during its historic submerged circumnavigation of the world.[150]

In 1960, a major innovation occurred when a technique was developed for making the antenna inboard-retrievable, enabling the crew to make repairs to the cable while the submarine was submerged.[151]

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[145] Ibid., p. 56-57.

[146] Ibid.

[147] Ibid., p. 54-55.

[148] Ibid.

[149] Ibid.

[150] Ibid.

[151] Ibid.

Single mast antenna stacking. Prior to the advent of satellite communications, the numerous cables (navigation, communication, and ESM) that were on a submarine were stored via coiling around the periscope mast. However, with developments in satellite communication, and the advent of various additional antennas, the need for a single all-purpose antenna arose.[152]

Initiated by New London Laboratory Engineers Andrew Stanland, Richard W. Garriazzo and John M. Comiskey, work began in the 1950s on an all-purpose multi-function mast antenna, which would eliminate the need for coiling an antenna.[153]

Physical Changes and Uses of Fort Trumbull in the 1950s

With the departure of the University of Connecticut in 1950, many buildings of the Fort Trumbull reservation were incorporated into the USL to be used as R&D and testing facilities. Buildings and their uses in the 1950s were the following:

- Building 39 -- submarine sonar developments
- Building 28 -- electromagnetic research
- Building 36 -- surface sonar
- Building 14 -- holographic research
- Building 44 -- testing chamber
- Building 43 -- supply depot and early warfare analysis
- Fort Trumbull -- antenna research, water tunnel and sound tunnel propagation research.

Architectural developments at New London in the 1950s included the demolition of the temporary barracks "Flying Cloud", to provide additional parking space, and the bulkheading and filling of part of Columbia Cove to provide additional land.

The Era of the Strategic Missile Submarine, 1960s

In 1960, the first strategic nuclear missile submarine, the USS *George Washington* (SSBN 598) was launched. The launching of this vessel presented new challenges to naval architects, planners, engineers, and personnel. The ability to carry nuclear missiles provided the military with a ship that could approach an adversary's shore undetected and without warning deliver a payload of nuclear weapons. Recognizing the potential of this vessel, the Navy also recognized the need for better

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[152] Ibid., p. 57.

[153] Ibid.

communications systems. Moreover, the numerous technological innovations of the past decade had considerably increased the size of sonar suites and the amount of electromagnetic sources onboard ships. These increases resulted in major design modifications in the size and shape of nuclear submarines.

Major R&D activities carried out by the Navy Research Laboratory in the 1960s included the following:

- integrated submarine sonar system
- blue-green laser (ship-to-ship underwater laser communications system)
- electromagnetic compatibility (ECM)
- further developments in Electronic Warfare Support Measures (ESM)
- advances in submarine satellite communications
- periscope and optical communications

Integrated Submarine Sonar System

In August of 1956, the Submarine Sonar Division at New London proposed to BUSHIPS an integrated sonar system. This system was designed to reflect the changes made possible by the nuclear submarine, namely, the potential to use the submarine in anti-submarine warfare. The operational characteristics created sonar needs that were not met by the post-World War II sonar systems. Earlier sonar systems were primarily passive, or listening, systems whose ranges were inadequate for acceptable echo-ranging performance. These older systems were predicated on the characteristics of older submarines, whose use of battery power and low speeds of operation provided a good environment for listening equipment. Nor were diesel submarines ever envisioned to engage in anti-submarine warfare. Nuclear submarines, with increased speed and size, required sonar systems with the capacity to operate in the presence of additional self-noise.[154]

In 1946, the average sonar suite had a footprint of about 325 cubic feet and weighed 10,400 pounds. By 1954, the sonar suite averaged 520 cubic feet and had 285,000 pounds of electronics and arrays (Merrill and Wyld, 1997).[155] Naval architects soon recognized that the weight, size, and importance of sonar would dictate that the a submarine's hull geometry, shape, and size would have to be designed to allow sonar suites the first choice in ship's space.[156]

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[154] Merrill and Wyld, op. cit., p. 42-43.

[155] Merrill and Wyld, op. cit., p. 40.

[156] Ibid., p. 41.

In 1964, the New London Laboratory assisted in the design of the Integrated Sonar system, prototype model AN/BQQ-2. This was the spherical bow array, the first model designed for submarine hulls. The array combines ship design with the use of a 15' diameter spherical active-passive array mounted in the bow, and continues to be an integral part of present-day submarine design.[157]

In addition to the development of the bow-mounted array, improvements were also made in the means of data transfer. Prior to the late 1960s, the operation and interpretation of sonar data had primarily been conducted manually using analog instruments, but nuclear submarines required a more sophisticated sonar system that would operate more quickly and efficiently. In the summer of 1969, Navy and laboratory personnel defined the capabilities of the new sonar system, determined how it could be incorporated (backfitted) into existing submarines, and planned for its use in a new class of attack submarines for carrier group escort. The new sonar system incorporated the latest in digital circuitry.[158]

Laboratory personnel were active in all stages of the process leading to the delivery of the new sonar system. Sonar engineers Herbert Fridge, John Soderberg, and John Pratt were among those working with Henry Cox and other Washington-based personnel. Five separate but interlocking patents were awarded to seven members of the laboratory for their work on the integrated spherical array.[159]

Electro-Optics (Blue-green Laser)

The Navy in the late 1960s turned to the USL to develop a secure ship-to-ship, line-of-sight optical communications system for use in certain naval operations where the broadcasting of a message over open airwaves might compromise the mission.

In 1965 and 1966, laboratory personnel conducted the first field measurements of underwater laser transmission in the waters off Bimini and Puerto Rico. The optical source used in these measurements was the first blue-green laser ever produced, which was manufactured under an Office of Naval Research (ONR) contract with RCA. Subsequent development efforts included the building of several receivers that were installed on submarines for testing laser communications at sea.[160]

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[157] Ibid., p. 43.

[158] Merrill and Wyld, op. cit., p. 49-50.

[159] Ibid.

[160] Merrill, op. cit., p. 62.

Electromagnetic Compatibility

Electronic devices and systems on aircraft, surface ships, and submarines create electromagnetic interference that may degrade the performance of communications and other warfare systems. With the amount of electronic equipment present on submarines steadily increasing, and especially with the advent of nuclear submarines and their increased mission times and nuclear strike potential, it became imperative to reduce electromagnetic interference in order to assure optimum system performance.

In the 1960s, concerted efforts were made at the laboratory in initiating work to increase electromagnetic compatibility (EMC). Work performed at the laboratory resulted in establishing EMC-oriented system performance requirements and key sonar and radio communications systems parameters. These techniques and procedures continue to this day as the basis for electronic warfare the EMC standards.

Developments in Electronic Warfare Support Measures (ESM)

One of the functions of a submarine is to lie undetected just below the surface and intercept transmissions (e.g. radar waves) of opposing forces. Interception equipment includes a number of devices known collectively as electronic support measures (ESM). During the 1960s, enemy radar began operating at higher frequencies undetectable by American submarine sensing equipment of the time, so that in order for submarine ESM to intercept the radar transmissions, the frequency ranges of the existing equipment had to be increased. USL Engineers David McQueeny and Richard W. Garriazzo successfully extended the frequency coverage of an existing-direction ESM system.

In 1967, the Reconnaissance, Electronic Warfare, Special Operations, and Naval Intelligence Processing (REWSON) project tasked the USL to assist in the technical evaluation of a new digitally-operated, mast-mounted, direction-finding system with no rotating antenna elements, which had been developed by Sanders Associates of Nashua, New Hampshire. In 1969, a prototype model of this system was installed onboard the submarine USS *Plunger* (SSN 595). A laboratory team headed by John Comiskey conducted tests from a surface ship to analyze the capabilities of the system under operational conditions.[161] Work with the new system continued and the laboratory assumed an extensive role in design review, testing, logistics analysis, and planning for the shipboard installations of the new systems in different classes of attack submarines.[162]

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[161] Ibid., p. 61.

[162] Ibid., p. 62.

Advances in Submarine Satellite Communications

In 1958, the U.S. Army had launched a battery-powered communications satellite, referred to as SCORE (Signal Communication by Orbiting Relay Equipment). This satellite demonstrated the effectiveness of transmitting real-time, instantaneous voice, code, and teletype messages. Realizing the advantages of real-time communications with another party anywhere on the globe, the Navy began to further investigate satellite communications for its vessels.

In January and February of 1965, the Navy, using a geosynchronous SYNCOM satellite, conducted a highly successful at-sea test of satellite communication. The test involved the naval vessels USS *Kingsport* (T-AG 164), USS *Midway* (CVA 41), and USS *Canberra* (CAG 2). On January 10, a satellite link was established between the *Canberra* and the *Kingsport*. On February 16, the *Canberra* and the *Midway*, separated by over 6,000 nautical miles, achieved a satellite link. Finally, on February 17, the *Canberra,* in rough seas driven by 40-knot winds, achieved voice communications with the *Midway* via satellite. The success of these tests marked the beginnings of tactical satellite communications.[163]

Encouraged by the success of the February 17 (1965) test, the Army, Navy, and Air Force established a tri-service Tactical Satellite Communication Program (TACSATCOM) to explore the potential of satellite communications and to demonstrate their feasibility.[164] The program manager for naval satellite communications tasked the New London Laboratory to undertake the work necessary to perform a submarine at-sea test demonstration of satellite communications using the orbital UHF LES-5, which was launched during July of 1967.[165]

Phase I of the satellite communications tests was scheduled for the period of July 2 to December 31, 1967. The New London Laboratory organized a team of submarine communication system engineers led by Edmond C. Bourque, who set up a satellite facility on Fishers Island. This field site was operated from July 1 until November 11, 1967. Beginning on September 5, the submarine USS *Sea Leopard* (SS 483) served as a satellite communications link terminal for the three sea tests. These tests offered the opportunity to analyze the ability of a submarine at varying depths to receive and transmit signals via satellite communication.[166]

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[163] Ibid., p. 58.

[164] Ibid.

[165] Ibid., p. 59.

[166] Ibid.

In 1968, the laboratory conducted a new round of tests using a satellite link to transmit signals via ultra high frequency (UHF) and extremely high frequency (EHF). The tests were initiated to assess the performance of the antenna and the system requirements of a submarine receiving these signals.[167]

Periscope and Optical Communications

In the 20 years following WWII, periscopes changed from being simple optical devices used for visual observation to a platform for mounting and incorporating communications, radar, and ESM antennas. During the late 1960s, advancements in technology and design yielded television and photographic equipment that could be added onto periscopes to enhance their optics.[168]

In the mid 1960s, work had begun in a Massachusetts facility on a new prototype periscope termed Type 18. Type 18 marked a new era in periscope construction and technology, incorporating such features as built-in, low-level television and photographic camera devices. The Navy tasked the New London Laboratory to provide in-house optical technology support for in-plant testing and submarine evaluation, implementation, and introduction to the fleet.

Work in optical communications for submarines at New London continued for nearly 20 years. In early 1967, the Reconnaissance, Electronic Warfare, Special Operations, and Naval Intelligence Processing (REWSON) division of NAVSHIPS assigned the laboratory an active role in on-going mast periscope systems developments involving both radio frequency and optics.

In addition to the work in optics being carried out at Fort Trumbull, in 1969, the USL acquired a laboratory on Diamond Island in Lake Winnipeasaukee, New Hampshire, which was originally a test center used by the Scripps Institution of Oceanography Visibility Laboratory. Here, USL personnel carried out experiments in the transmission of coherent and non-coherent light[169]

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[167] Ibid., p. 59-60.

[168] Ibid., p. 57.

[169] NUSC ECHO, Newsletter, 1969. On File at NUWC Public Affairs Office, Newport, Rhode Island.

Architectural Developments at Fort Trumbull in the 1960s

Two major construction projects were completed at Fort Trumbull in the 1960s:

- In September of 1962, construction of the H-Building (Building 80) was completed at a cost of more than four million dollars. The building provided over 175,000 square feet for new offices and laboratories.[170]

- In 1965, a new 700' long pier was built, designed to accommodate most of the ships in the American fleet at the time [171]

The Naval Underwater Systems Center (NUSC), 1970-1989

In the late 1960s, in search of fiscal efficiencies and under the influence of the "systems approach" management theory then in vogue, the Navy began to examine the possibility of combining various research efforts and facilities by general type. This effort resulted in the merger of the USL with the Underwater Weapons Research and Engineering Station, at Newport, Rhode Island, into the Naval Underwater Systems Center (NUSC). One of six research and development systems centers created by the Secretary of the Navy, NUSC combined USL's technological expertise in sonar, electro-optics, and electromagnetics with the underwater weapons systems expertise of the Newport facility. The USL became known as NUSC New London.[172]

Despite the merger, the mission of the NUSC New London did not change, and research was still focused in the four general areas of submarine sonar, surface sonar, electro-optics, and electromagnetics, including Electronic Warfare Support Measures (ESM). Additionally, two new areas of research and expertise were added to the NUSC repertory, comprised of Land-Based Integration and Testing Systems (L-BITS) and Warfare Analysis and Simulation.

Virtually every area of research and development at NUSC followed a single trend. A series of individual technological systems would first be developed and then these discrete systems would be integrated through the development of some form of overarching combat control system.

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[170] Merrill, op. cit., p. 35.

[171] NUSC ECHO, Newsletter, 1969. On File at NUWC Public Affairs Office, Newport, Rhode Island.

[172] Merrill, op. cit., p. 64, Merrill and Wyld, op. cit., p. 10.

Submarine Sonar

In the early 1970s, submarine sonar research and development at NUSC New London was dominated by efforts to upgrade sonar systems for attack submarines, primarily through the development of towed array systems. This task began with development of the Submarine Tactical Array Sonar System (STASS), a towed array upgrade for 594- and 637-class attack submarines. Implemented in 1971, the success of STASS resulted in the development of the AN/BQQ-5 Integrated Submarine Sonar System. This new system, designed for the Los Angeles (688) class submarines that were on the way, included towed array and spherical bow sonars that could provide long range sonar performance. These detection arrays were linked to new computers that permitted multi-target tracking as well as enhanced target detection and classification. The development of the AN/BQQ-5 was paralleled by the development of a similar system, the AN/BQQ-6, for the Trident class ballistic missile submarines.[173]

As submarines with the AN/BQQ-5/6 system put to sea, NUSC New London was developing more accurate sensors. In the early 1970s, sonar researchers developed a wide aperture sonar array (WAA) to assist in the rapid passive location of underwater threats. These arrays consist of massive (approximately 12' by 18') passive sonar listening panels, arranged three to a side on an attack submarine. The WAA sensors were augmented by a new generation of long, thin-line, highly sensitive, passive towed arrays. In combination, the two systems permitted an attack submarine to passively detect, classify, localize, and track any source of acoustic energy. These systems began to appear on 688-class submarines commissioned after 1985, such as the USS *Augusta* (SSN-710).[174]

These improvements in sonar technology, combined with improvements in signal processing made possible by sophisticated microprocessors and computers, and new weapons technology (cruise missiles and new torpedoes), called for the creation of a new advanced combat system that could electronically integrate submarine sonars (active and passive), tracking (fire control) and weapon targeting and firing. Completed around 1985, this combat system, designated AN/BSY-1, was developed for 688-class submarines and first used on the USS *San Juan* (SSN-751), while a second system, AN/BSY-2, was developed for the Seawolf-class (SSN-21) submarines that were still on the drawing board.[175]

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[173] Merrill and Wyld, op. cit., p. 48-52.

[174] Ibid., p. 52-54.

[175] Ibid., p. 55-56.

Surface Sonar

Surface sonar research at NUSC New London covered a broad range of technologies, many of which were follow-ons to primary research conducted in the 1950s and 1960s. In the early 1970s, NUSC New London helped to improve the aging SQS-26 sonar systems, and then contributed to the development of the next generation of surface sonar, the SQS-35C. During the 1970s and 1980s, NUSC New London also developed a new generation of variable-depth sonars (SQS-35 (V)), and four generations of tactical passive towed arrays (AN/SQR-14, 15, 18, and 19). By 1987, the AN/SQR-18 was operational on over 40 Knox-class (FF-1052) frigates. In addition to work on towed arrays, NUSC New London was also involved in the development of other off-hull anti-submarine warfare (ASW) systems, including the information-processing system for the LAMPS Mark III, a shipboard anti-submarine helicopter.[176]

At the same time, NUSC New London developed a shipboard computerized system that, given oceanographic information and the ship's position, can select the best operating mode for the ship's sonar. Initially known as SIMAS (Sonar In-situ Mode Assessment System) and later designated AN/UYK-25, the system became operational in the early 1980s. It has been installed in over 170 ships.[177]

As with submarine sonar, the series of new surface sonar developments in the 1970s and 1980s made information management and processing critical. To manage all ASW information and integrate it with anti-air and anti-ship warfare information, NUSC New London developed the SQQ-89 Sonar/Fire Control Integrated Combat System. This system links and integrates all information from hull-mounted sonar, towed arrays, the LAMPS helicopter, and the ship's fire control system to provide a ship's weapons officer with a single complete picture of potential ASW threats.

Electro-Optics and Periscopes

With the completion of the development, testing, and limited installation of the Type 18 periscope in 1972, a decision was made to outfit all SSN-637- and SSN-688- class attack submarines with the Type 18, which was done by the mid-1980s. NUSC New London's work on the Type 18 led to the selection of NUSC, in 1974, as the agent for the developing the periscope for the Ohio-class (SSBN-726) ballistic missile submarines carrying Trident missiles. After success in developing this Trident

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[176] Merrill and Wyld, op. cit., p. 62-90.

[177] Ibid., p. 70

periscope, as it became known, NUSC New London developed a shorter version for older strategic ballistic missile submarines.[178]

In 1984, NUSC New London was tasked with the development and deployment of a wide range of special periscope sensors and systems, from laser detectors to a periscope-mounted automatic direction finding system (ADF). NUSC New London was then assigned to oversee the development of a new periscope, the Type 22, which was designed to be as versatile as possible, accommodating a maximum variety of sensor packages. By 1986, a prototype Type 22 was undergoing at-sea tests (Merrill and Wyld, 1997).[179]

Other electro-optic work at NUSC New London focused on fiber optics and underwater laser-based communication. From 1974 on, NUSC New London personnel developed fiber optic-based systems for submarines, leading to research into a fiber optic-guided torpedo and an all-optical towed sonar array. Since the successful testing of underwater laser communications in the late 1960s, personnel continued to conduct research in this field.

Electromagnetics and ESM

Most of the electromagnetic-related developments at NUSC focused on communication. Engineers and scientists at NUSC developed new towed buoy and mast-mounted antennae for submarines. Most importantly, researchers continued investigation into the development of new communications techniques for submarines, including the use of satellites and extremely low frequency (ELF) radio waves.

Communication via satellite with a submerged submarine was achieved through the development of an expendable UHF communications buoy. The buoy, operational in 1982 as the AN/BRT-6, is launched from a submarine at depth and under way, transmits or receives a message and then sinks, reducing the chance of detection.[180]

Communication via ELF was further developed, as it was seen as an improvement over the existing VLF systems because it permitted reception at even greater depths. In conjunction with the Lincoln Laboratory at MIT and several private contractors, personnel at NUSC New London developed a

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[178] Ibid., p. 205.

[179] Merrill and Wyld, op. cit., p. 207.

[180] Ibid., p. 212-214.

complete ELF communications system. The system was first used operationally in 1976 aboard the USS *Batfish* (SSN 681) and was fully operational for the full submarine fleet by 1989.[181]

During the 1960s, opposition force radars began to operate at higher frequencies, limiting the usefulness of the existing ESM system, the AN/BRD-6. In the late 1960s and early 1970s, NUSC personnel assisted in the development of new mast-mounted ESM antennae. Unlike earlier systems, the new ESM system had no rotating antenna elements and used digital electronics to make direction- finding measurements. Designated AN/BRD-7, this system was fleet-operational in SSN-637-class submarines in the early 1970s. In the late 1970s and early 1980s, NUSC personnel participated in improving the ESM capabilities of 688-class submarines, producing new systems designated AN/WLQ-4 and AN/WLR-8.[182]

L-BITS

As can be deduced from the above information, much of the sonar-related activity at NUSC New London focused on systems integration, ensuring that sonar systems developed by NUSC could be easily incorporated into existing ships and submarines. To this end, full-scale Land-Based Integrations Testing Sites were constructed, initially in Building 80 and, after 1974, in Building 96, which was purposely built as a high bay test facility for fleet integration testing. Inside these buildings, full-scale mockups of submarine conning towers and ship combat control centers were built as test beds, virtually eliminating costly shipboard testing and integration procedures.[183]

Warfare Simulation

In the early 1970s, NUSC New London began to develop computer simulations of fleet operations. This resulted in the further development of a pre-existing computerized simulation program, known as SIM II, to assess the effect of new combat subsystems (standoff weapons, cruise missiles, advanced capability torpedoes, and improved acoustic sensors) at both the shipboard effectiveness level and at a larger fleet-operational and tactical level. Significant analyses, conducted from 1979 to 1990, included the following:

- alternative designs to follow the SSN 688-class submarines
- effectiveness of towed arrays and a variety of other major weapons systems
- performance of the 688-class submarines against evolving threats

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[181] Ibid., p. 214-216.

[182] Merrill and Wyld, op. cit., p. 216-219.

[183] Ibid., p. 81 ff.

- threat projections
- design of the *Seawolf*-class submarine.[184]

Construction of Buildings 94, 99, and 101, and Fort Trumbull Building Utilization

In order to support the increased testing and development of periscopes and communications equipment, three major new buildings were constructed at NUSC New London in the 1970s and 1980s -- Buildings 94, 96, and 101. Building 94 was designed solely for Research, Development, Testing and Evaluation (RDT&E) of periscope systems. Prior to its construction, vertical testing of periscopes was achieved by using a crane to insert them through a hole in the roof of Building 80. Completed in 1974 and enlarged in 1986, Building 94 included a 19.8-meter (65-foot) tower for vertical testing of Type 18 and subsequent periscopes.

Building 96, also completed in 1974, is a massive five-story structure that consists of a large central test bay surrounded by offices and small workshops. The construction of this building permitted the extensive use of full-size mock-ups for NUSC New London's extensive L-BITS program. The central test bay is large enough to accommodate a full-scale model of a submarine conning tower, complete with antennae and periscopes.

Building 101, the Submarine Over-Water Arch facility, was completed in 1981. It was relocated to NUWC Newport at the commencement of the survey in 1997. It consisted of a raised, reinforced-concrete, salt-water pool with a central well for antenna placement, and three 70-foot-radius, laminated wood arches. The facility simulated the submarine operating environment for all forms of submarine antennae. The laminated wood beams formed a full zenith arch, so that antenna characteristics could be measured at all azimuth and elevation angles above the water surface.[185]

With a staff of approximately 1,500 during the 1970s and 1980s, research at NUSC New London occurred in virtually every building, from the fort to converted barracks. In addition to Buildings 94, 99, and 101, Building 80 remained one of the hubs of all aspects of research. The research use of all buildings is summarized in Table 6.

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[184] Ibid., p. 227-243.

[185] See Planning Documents in NUWC Newport Public Works Office Files, Newport, Rhode Island.

Naval Undersea Warfare Center (NUWC) New London and Base Closure, 1990 to 1996

As a result of the Base Closure and Realignment Committee's (BRAC) recommendations of 1990, NUSC New London was again realigned to become more closely linked with its sister facility in Newport, Rhode Island. Consequently, in 1991, NUSC New London was redesignated the Naval Undersea Warfare Center (NUWC) New London. Its mission remained essentially the same as the mission of NUSC. Research facilities at NUWC New London were improved with the construction of Building 2 (1994), devoted to surface sonar research. In 1995, per BRAC's 1995 recommendations, NUWC New London was ordered closed, to be consolidated with NUWC Newport. In March, 1996, all of NUWC New London's operations were transferred to Newport and today the site stands vacant.

Table 6
Buildings Used for Research at NUSC New London, 1970-1989

Building No.	Research Use
14	Holography
28	Electromagnetics
32	Sonar
34	Optics
36	Surface Sonar
39	Submarine Sonar (temporary use)
43	Warfare Analysis
44	Testing Chamber
80	Sonar, L-BITS, Electro-optics
94	Electro-Optics
96	L-BITS, Fleet Integration Testing
101	Satellite Communications
Source: John Merrill, 1997, Electronic Engineer Emeritus, NUWC/New London. Personal Interview, August 1, 1997. Note: Due to the classified nature of most of the research conducted at NUSC New London, this list may be incomplete.	

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Engineering and site maps of the base during the Revolutionary War can be found at the New London County Historical Society, New London Connecticut. These maps are copyrighted. Site plans and plans of individual buildings are available in two collections at the National Archives, Cartographic Branch in College Park, Maryland: RG 77, Records of the Office Of The Chief of Engineers and RG 92, Records of the Office Of The Quartermaster General. Dozens of drawings of every building currently extant at NUWC are now located in the files of the Caretaker Site Office, Naval Undersea Warfare Center, New London.

B. Historic Views

Nineteenth and early twentieth century views of the base are available in three collections at the National Archives, Cartographic Branch in College Park, Maryland: RG 77, Records of the Office Of The Chief of Engineers; RG 92, Records of the Office Of The Quartermaster General; and RG 26 Records of the U.S Coast Guard. Aerial views of the base from c. 1942 to 1993 are also found in the Photo lab and Public Affairs office files of the Naval Undersea Warfare Center, Newport, Rhode Island. Dozens of photographs of each individual building (dating from 1950 to 1998) can be found in the files of the Caretaker Site Office, Naval Undersea Warfare Center, New London.

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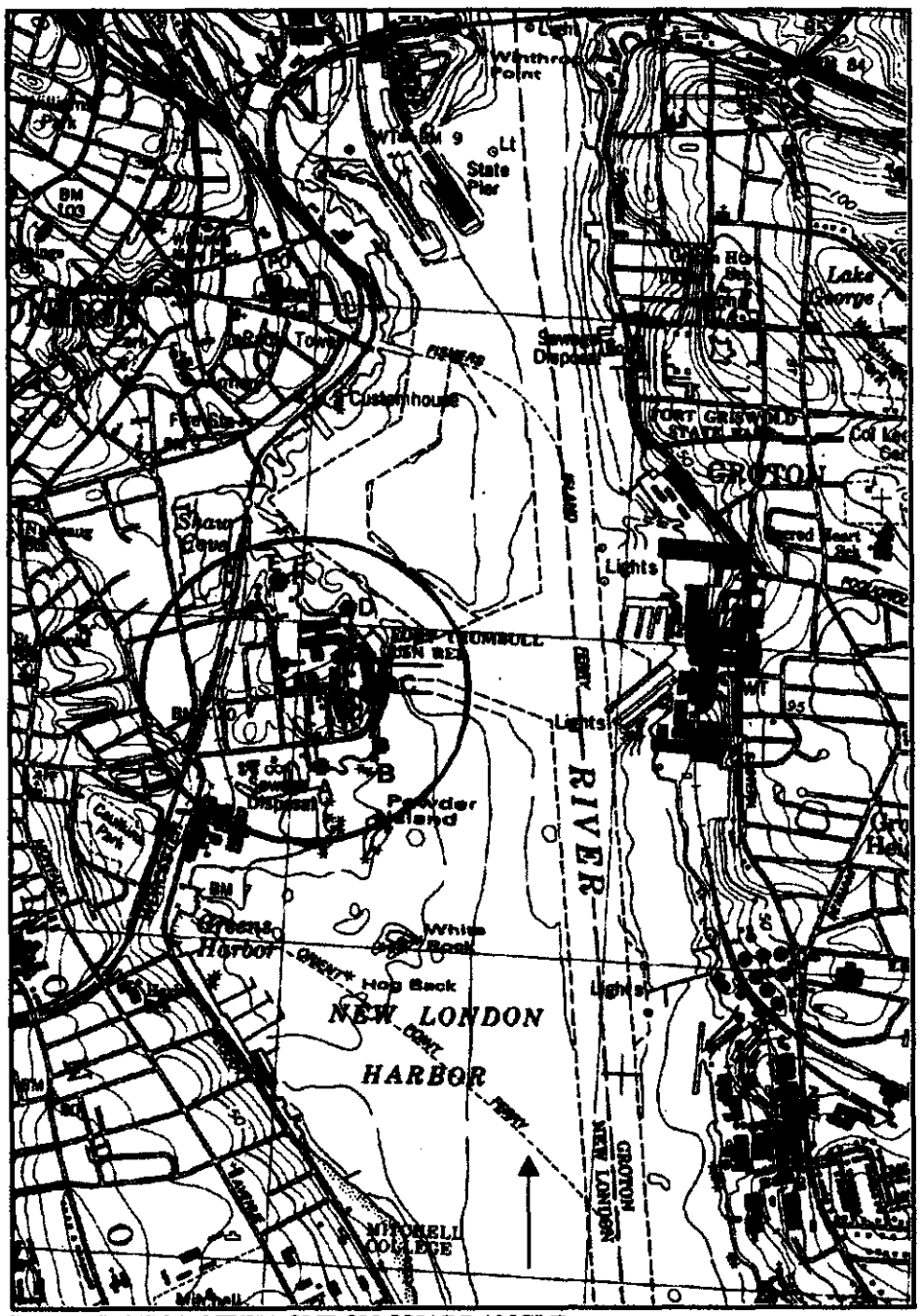
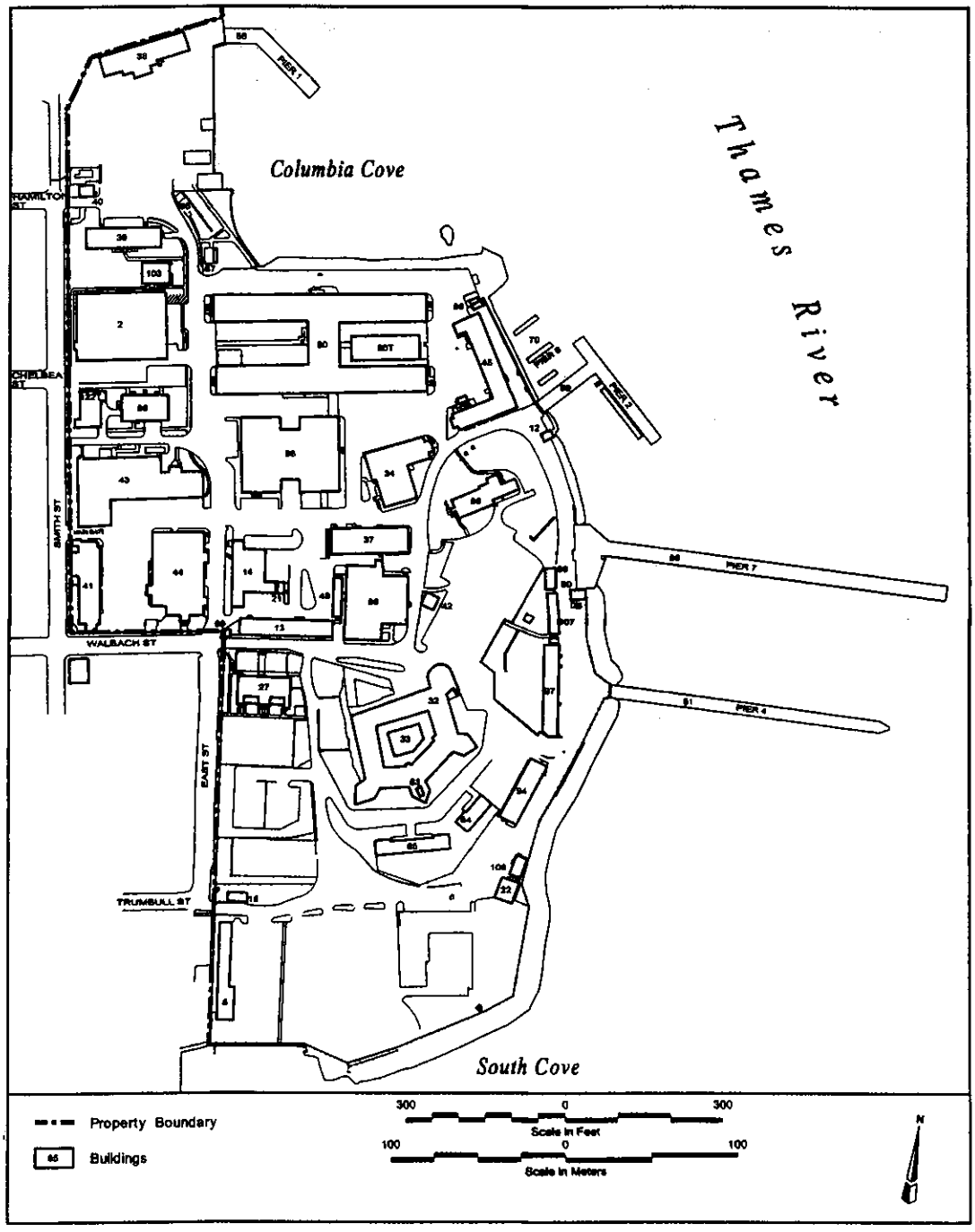
LOCATION MAP



SOURCE: USGS: NEW LONDON QUADRANGLE

Naval Undersea Warfare Center New London Site



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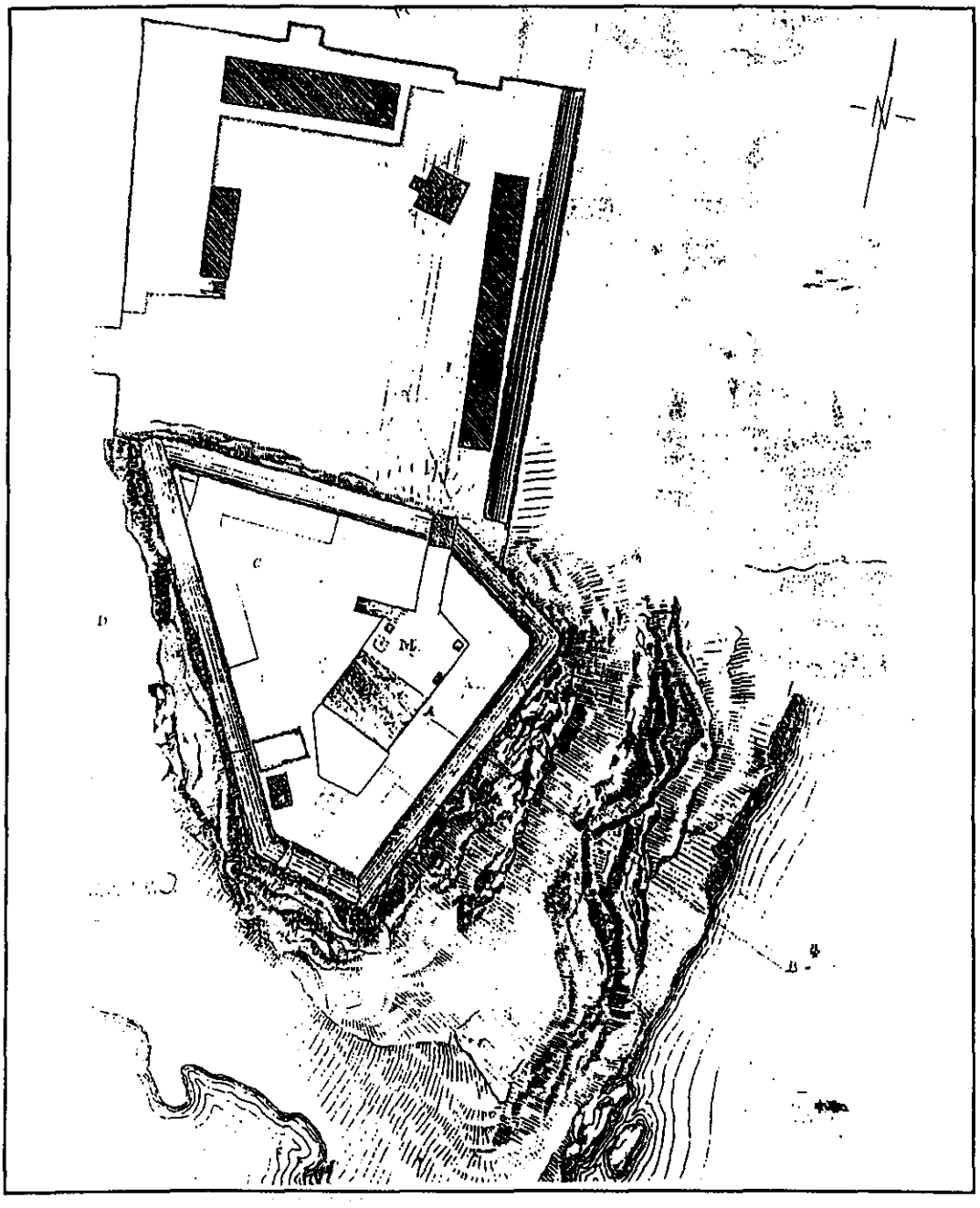
Plan and Profile of Fort Trumbull, c. 1812



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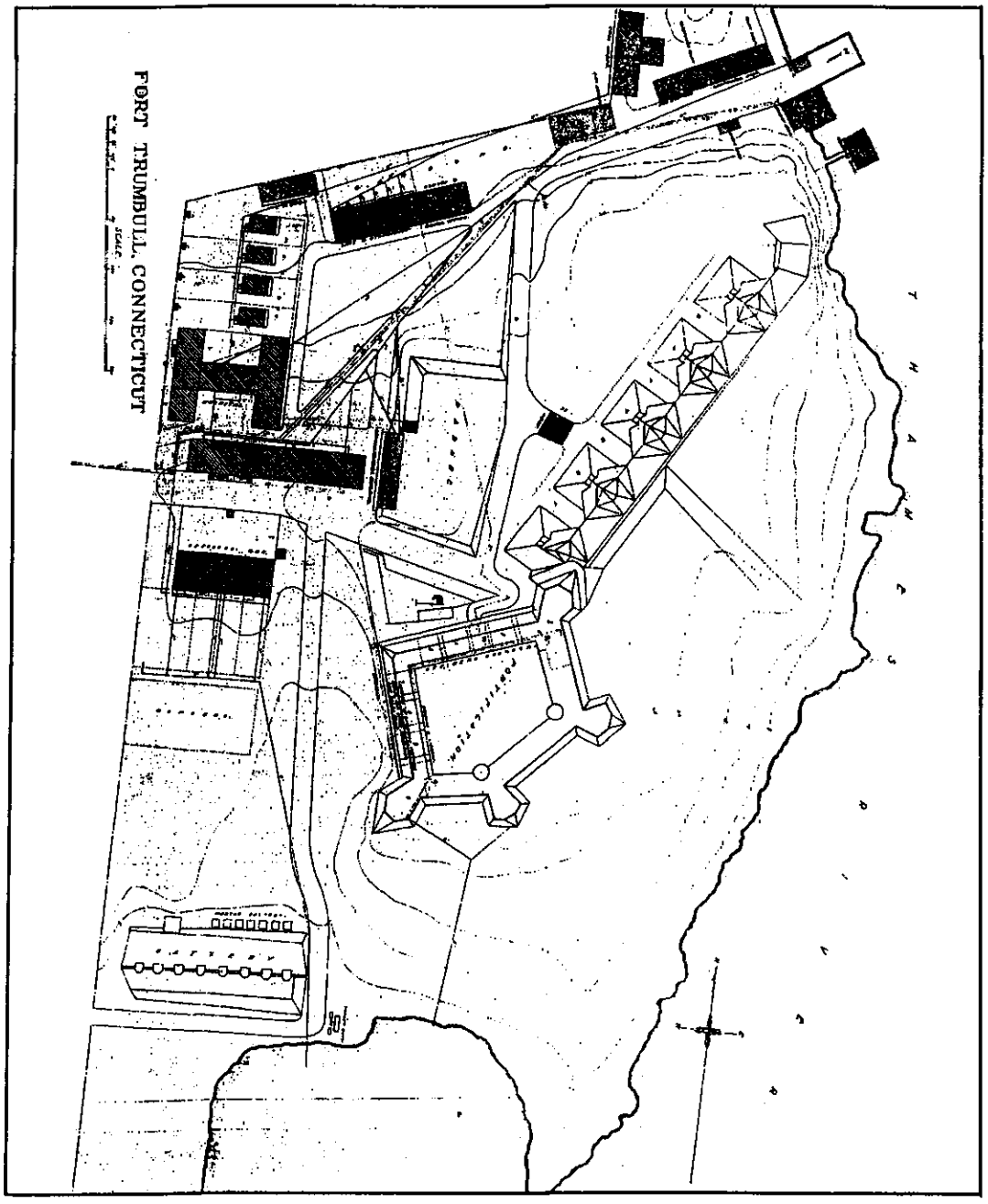

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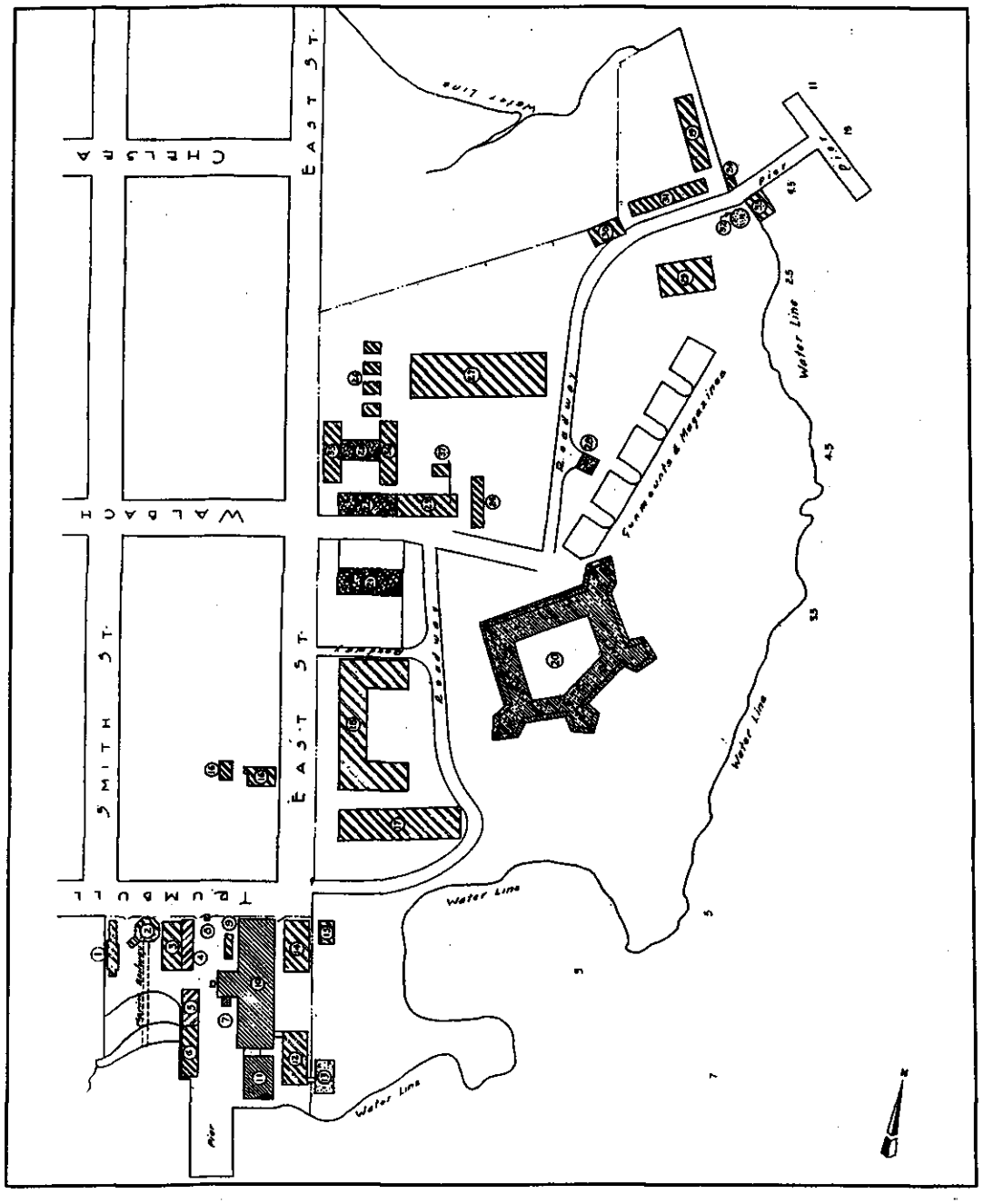
Fort Trumbull and Environs, 1918



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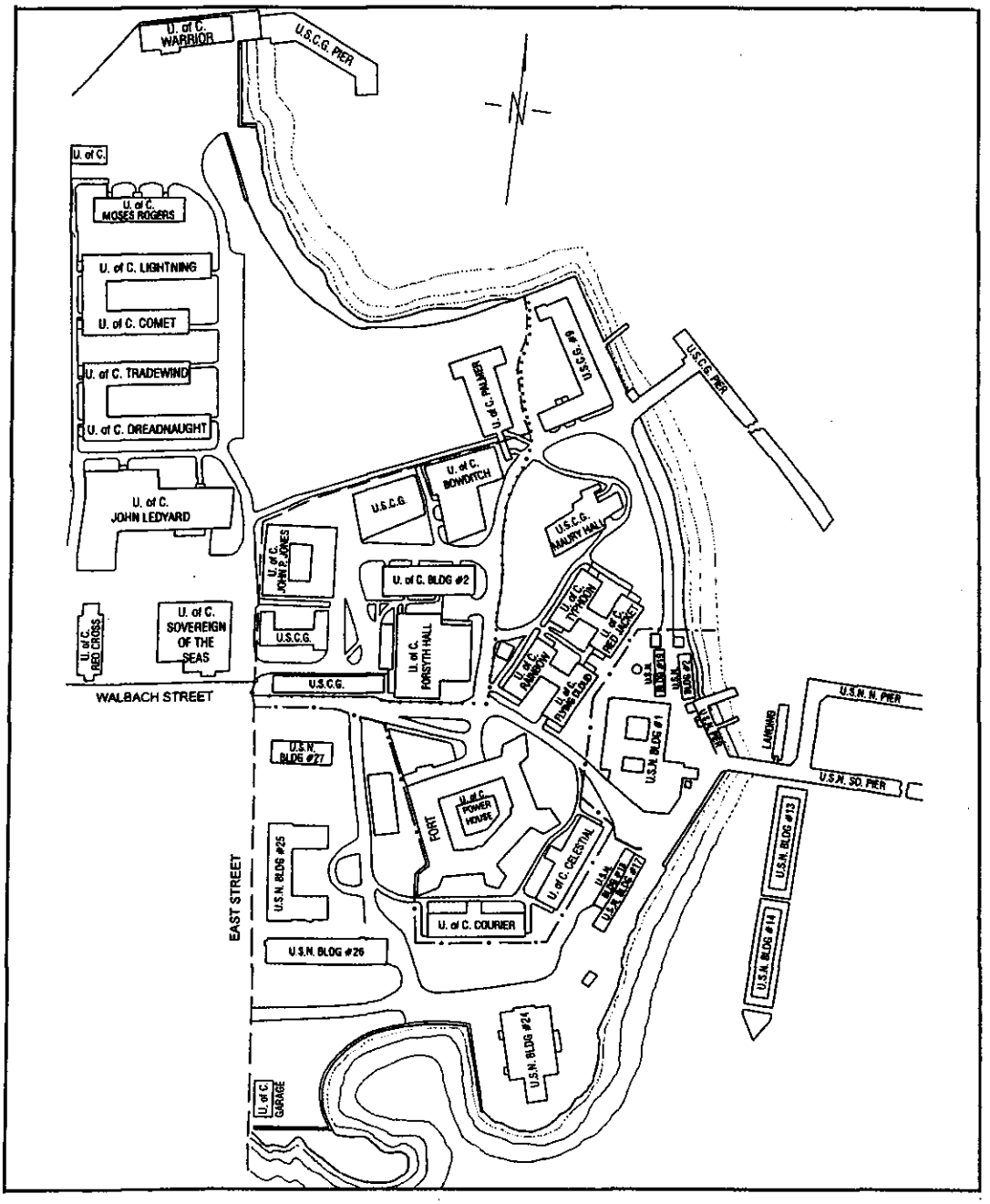

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